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WHS

"World Halal Summit"

Halal 2026 Congress



12th WORLD HALAL SUMMIT

Sustainable Halal Economy: Eliminating Waste, Empowering Growth

25-27 November 2026

İstanbul Expo Center / Türkiye

Halal 2026 Congress

"World Halal Summit"

DÜNYA HELAL ZİRVESİ

WORLD HALAL SUMMIT

Sürdürülebilir Helal Ekonomi:
Atığı Ortadan Kaldırmak, Büyümeyi Güçlendirmek

Sustainable Halal Economy: Eliminating Waste, Empowering Growth

25 - 27 KASIM 2026

25 - 27 NOV 2026

İSTANBUL

CONGRESS PROCEEDINGS

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Dear Researchers, Experts, Scientists, Industry Professionals, and Distinguished Colleagues,

It is our great pleasure to invite you to the World Halal Summit Halal Congress 2026 organized within the framework of the 12th World Halal Summit (WHS), to be held under the auspices of the Presidency of the Republic of Türkiye, under the theme of "Sustainable Halal Economy: Eliminating Waste, Empowering Growth" on 25–27 November 2026 at the Istanbul Expo Center, Istanbul, Türkiye.

The Summit will be held concurrently with the Halal Expo 2026 (25–28 November 2026) and is jointly organized by Discover Events, in association with the Standards and Metrology Institute for Islamic Countries (SMIIC), an affiliated institution of the Organization of Islamic Cooperation (OIC), and Lokman Hekim University.

Bringing together academia, industry, government institutions, and international organizations, this landmark event will serve as a global platform for advancing the Halal ecosystem through collaboration, innovation, and knowledge exchange.

Together, the 12th World Halal Summit and the Halal Expo 2026 will provide a unique opportunity for researchers, policymakers, entrepreneurs, and industry leaders to exchange expertise and explore emerging developments across the diverse sectors of the Halal economy, including Halal awareness, zero-waste, Halal food and beverages, Halal industry technologies, cosmetics and personal care, pharmaceuticals, tourism, Islamic finance, modest fashion, logistics, Halal quality infrastructure, and other related industries.

In the previous edition of the World Halal Summit, we proudly welcomed 48 distinguished international speakers from 16 countries across 10 insightful sessions, each dedicated to advancing the global Halal industry and ecosystem through knowledge sharing, meaningful discussions, and strategic dialogue.

The scientific programme, WHS Halal Congress 2026, will feature distinguished keynote speakers, plenary lectures, panel discussions, technical sessions, and scientific presentations addressing the most pressing challenges and emerging opportunities within the global Halal industry. Participants will have the opportunity to share cutting-edge research, discuss innovative solutions, establish international collaborations, and contribute to shaping the future of the sustainable Halal economy.

Guided by this year's theme, "Sustainable Halal Economy: Eliminating Waste, Empowering Growth," the Summit aims to promote sustainable production and consumption, responsible resource management, circular economy approaches, technological innovation, and resilient Halal value chains that support long-term economic growth and societal well-being.

We warmly invite researchers, academicians, professionals, policymakers, industry representatives, entrepreneurs, and students from around the world to contribute to the scientific programme and become part of this distinguished international gathering. We look forward to receiving your submission and to welcoming you to Istanbul for World Halal Summit Halal Congress 2026.

With our sincere regards,

World Halal Summit Organizing Council

İhsan Övüt	**Prof. Dr. Fatih Gültekin**	**Yunus Ete**
General Secretary of SMIIC	President of Lokman Hekim University	President of the World Halal Summit Council, Discover Events Chairman of the Board

Dear Distinguished Scientists, Industry Representatives and Esteemed Stakeholders,

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Sustainability, resource efficiency, the zero-waste approach, and the circular economy are shaping the future of the halal ecosystem. In this context, the Congress will serve as an international platform to promote the scientific exchange of knowledge, strengthen global collaboration, and advance sustainable solutions across the halal economy.

The programme will bring together academics, researchers, policy and decision-makers, and industry leaders. Alongside keynote lectures by internationally renowned experts, it will feature oral and poster presentation sessions as well as industry-led special sessions. We would be honoured to welcome you to this international scientific gathering in Istanbul, where continents and cultures meet.

Prof. Dr. Hasan Yetim
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(O-01) CIRCULAR HALAL ECONOMY: TURNING WASTE INTO SUSTAINABLE GROWTH

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Abstract

The rapidly expanding global halal economy presents significant opportunities to integrate sustainability, resource efficiency, and economic development. However, conventional linear production systems generate substantial waste, environmental challenges, and economic losses. Globally, approximately 1.05 billion metric tons of food waste were generated in 2022, highlighting the urgent need for sustainable resource management. This paper aims to develop a conceptual framework for a circular halal economy by integrating Islamic principles of halal and Tayyib with circular economy strategies to transform waste into valuable resources while maintaining halal integrity.

The study employs a narrative literature review and conceptual analysis of halal requirements, waste valorization technologies, sustainable processing practices, and circular economy applications. Potential applications include converting permissible food-processing by-products into value-added food ingredients, animal feed, fertilizers, biodegradable packaging, cosmetics, pharmaceuticals, and renewable energy. Examples include protein recovery from poultry-processing by-products, extraction of functional ingredients from fruit and vegetable residues, and conversion of organic waste into biogas and compost.

The analysis highlights critical challenges, including Shariah compliance of recovered materials, cross-contamination with non-halal substances, inadequate segregation and traceability, food safety concerns, and inconsistent certification standards. Emerging technologies, including artificial intelligence, digital traceability, advanced processing systems, and improved supply-chain management, can enhance resource recovery while safeguarding halal integrity.

The proposed framework recommends developing harmonized halal guidelines for by-product utilization, implementing effective segregation and traceability systems, strengthening collaboration among religious scholars, certification bodies, scientists, regulators, and industry, and encouraging investment in sustainable processing technologies. Integrating circular economy practices with halal and Tayyib principles can reduce waste and environmental impacts, generate new economic opportunities, create green employment, and strengthen food and resource security. A circular halal economy offers a practical and ethically responsible pathway toward sustainable growth while aligning Islamic values with scientific innovation and environmental stewardship.

Keywords: Circular halal economy; Halal and Tayyib; Waste valorization; Sustainable development; Resource recovery

(O-02) "FUTURE FORESIGHT OF HALAL SUSTAINABLE TECHNOLOGIES: FOOD AND ANIMAL WASTE INDEX"

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Abstract

The global demand for ethical and environmentally responsible products has accelerated interest in Halal sustainable technologies. Integrating the principles of halal (permissible) and tayyib (pure and wholesome) into modern innovation creates new opportunities across agriculture, food production, pharmaceuticals, cosmetics, and bio-based industries. These sectors increasingly seek solutions that uphold both sustainability standards and Halal integrity.

This study introduces the Animal Waste Index (AWI) as a structured tool for evaluating the management and environmental impact of animal waste in agricultural systems. AWI enables transparent tracking of waste conversion into compost through Halal-aligned processes, enhanced by real-time monitoring and digital data collection. In parallel, Ecodrum technology demonstrates scalable innovation in food and organic waste management, converting organic matter into nutrient-rich compost through controlled aerobic and anaerobic processes. Together, these approaches reduce environmental burdens, improve soil health, and strengthen Halal-compliant agricultural practices.

By integrate situating AWI and Ecodrum within the broader Halal ecosystem, this research highlights the strategic opportunity to Halal principles with environmentally responsible technologies. Emerging applications in animal welfare, sustainable materials, Biotechnology applications, circular economy models, and bio-based materials reflect a paradigm shift toward resilient Halal value chains that advance sustainability while reinforcing Halal integrity.

Keywords: Animal Waste Index, sustainability, Halal, Ecodrum, waste management.

(O-03) CIRCULAR HALAL PHARMACEUTICAL GOVERNANCE FOR REDUCING WASTE AND PROTECTING PATIENT TRUST IN HEALTHCARE SUPPLY CHAINS

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Abstract

Healthcare systems face a linked governance challenge: medicines must remain safe, effective, halal-assured and continuously traceable, while avoidable pharmaceutical waste must be prevented across procurement, storage, dispensing, returns and disposal. Expired medicines, unused stock, damaged cold-chain products and poorly managed returns create financial loss, environmental risk and potential harm to patient trust. In halal healthcare systems, fragmented visibility of ingredients, production inputs, storage conditions, transport and disposal also weakens assurance of halal integrity. Global halal pharmaceutical consumer spending reached United States dollars 108 billion in 2022 and is forecast to reach United States dollars 142 billion by 2027, increasing the strategic importance of reliable and sustainable governance across the pharmaceutical value chain.

This study develops a Circular Halal Pharmaceutical Governance Framework for healthcare supply chains. It applies a qualitative review of international guidance on pharmaceutical waste management, circular supply-chain practice and halal pharmaceutical assurance, supported by comparative examination of regulatory and operational approaches in selected Organisation of Islamic Cooperation markets. The framework integrates halal critical control points with medicine life-cycle governance, from supplier qualification and demand forecasting to inventory control, patient dispensing, take-back systems, reverse logistics and safe final disposal.

Preliminary findings identify five connected governance pillars: halal-assured sourcing and supplier due diligence; demand-based procurement and first-expiry-first-out inventory management; end-to-end batch-level traceability; safe returns, reverse logistics and disposal; and transparent accountability through audit, reporting and patient communication. The framework recommends shared data standards for halal status, expiry and cold-chain integrity; risk-based audits of suppliers and distributors; contractual return arrangements for near-expiry stock; pharmacist-led medicine take-back mechanisms; and performance indicators for avoidable expiry, stock loss, recovery and safe disposal.

The proposed framework moves pharmaceutical waste management beyond end-of-pipe disposal towards prevention, value preservation and verifiable halal integrity. It provides regulators, manufacturers, hospitals, distributors, certifiers and healthcare providers with an implementable pathway to reduce waste, strengthen patient safety and protect trust in sustainable halal healthcare systems.

Keywords: Halal pharmaceuticals, circular economy, pharmaceutical waste, traceability, patient trust

(O-04) BEYOND PHYSICAL WASTE: ḤUQŪQ-E-MUJARRADAH AS A GROWTH MECHANISM IN THE HALAL ECONOMY

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Abstract

The global halal economy ignores a massive hidden and invisible loss: dormant intangible rights. While physical waste dominates sustainability discussions, valuable certification licenses, shared access rights, and trade quotas sit entirely unused. Classical Islamic jurisprudence recognizes these assets as Ḥuqūq-e-Mujarradah. Grounded in AAOIFI Shariah Standard No. 42 and recent market precedents, this paper unlocks these dormant assets as active growth mechanisms. This study presents a dual quantitative framework to bridge doctrine and practice. First, an operator-level Net Present Value (NPV) model evaluates the financial return of leasing idle usufruct capacity via Ijarah. Second, a sector-level bounding model projects that unmonetized rights tie up on the order of tens to hundreds of billions of dollars (US$53–320 billion across three illustrative scenarios) across the global halal market. The paper closes with targeted recommendations for standard-setters, certification bodies, Islamic financial institutions, and halal-economy data bodies. The study claims that eliminating this hidden waste is itself a growth mechanism, not a separate initiative running alongside one.

Keywords: Huquq-e-Mujarrada; intangible rights; AAOIFI Shariah Standard No. 42; halal economy; sukuk

(O-05) ETHICAL CONSUMERISM IN ISLAM: THE CONVERGENCE OF KHILAFAH, ISRAF, TABZIR AND IQTISAD.

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Abstract

The concept of environmental sustainability, sustainable production and consumption of food and other products are grounded in the religion of Islam. For instance, Islam regards humans as Khilafah or guardians of nature, which suggests that humans are put in charge of the environment to safeguard it for future generations. Therefore, the natural environment needs to be protected by avoiding over-farming, over-grazing over-fertilisation of soil and the pollution of water bodies.

The religion of Islam encourages sustainability by discouraging Tabzir (wastefulness) and Israf (extravagance) whilst promoting Iqtisad or Wasatiyyah (moderation). If Muslims were to adopt these principles, issues such as climate change, environmental pollution, and the prevalence of health issues such as obesity, cardiovascular diseases and neurological disorders such as strokes would be eliminated.

In this presentation, the author aims to suggest strategies for the Muslim-world to encourage regenerative agriculture and the consumption of balanced diets to protect the environment and promote human health. By adopting these strategies, Muslims will satisfy the principles of Khilafah, Tabzir, Israf, and Iqtisad.

Keywords: Climate change, Health, Sustainability, Cardiovascular, Food

(O-06) FROM HALAL COMPLIANCE TO INTELLIGENT ASSURANCE: AN AI-POWERED FRAMEWORK FOR FOOD SAFETY, TRACEABILITY AND COMPETENCY

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Abstract

The global halal food sector is expanding rapidly, increasing the need for assurance systems that address not only halal compliance but also food safety, traceability, workforce competency and consumer confidence. Traditional assurance models often depend on periodic audits, document verification and standardized training. While these remain essential, advances in artificial intelligence (AI) and digital technologies offer opportunities to shift towards more proactive, risk-based and intelligent assurance systems.

This paper proposes an AI-Powered Halal Food Assurance Framework integrating three interconnected dimensions: food safety and halal risk intelligence, digital traceability, and competency development. The framework explores how data from inspections, audits, laboratory results, certification records, supply-chain activities and historical non-conformities could be analyzed to identify emerging risks and prioritize regulatory or organizational interventions. Digital traceability can strengthen visibility across the food chain and support verification of critical halal control points, while AI-assisted analytics can help identify patterns and potential areas of non-compliance requiring human assessment.

A further component of the framework is competency assurance. Rather than relying exclusively on standardized periodic training, AI-enabled learning systems could use audit findings, operational activities and competency assessments to provide targeted microlearning, scenario-based exercises and continuous professional development for personnel responsible for halal and food-safety controls.

The proposed model maintains human oversight, transparency and accountability as fundamental principles, positioning AI as a decision-support mechanism rather than a replacement for qualified halal authorities, auditors or food-safety professionals.

By connecting halal integrity, food safety, traceability and human competency within a unified digital ecosystem, the framework provides a future-oriented approach for regulators, certification bodies and food businesses seeking to progress from periodic compliance towards continuous and intelligent halal assurance.

Keywords: Halal assurance, artificial intelligence, food safety, digital traceability, risk-based regulation, competency development, smart regulation

(O-07) STRENGTHENING PAKISTAN'S HALAL MEAT VALUE CHAIN THROUGH BY-PRODUCT VALORIZATION AND SUSTAINABLE FOOD PACKAGING: A SWOT–TOWS ANALYSIS

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Abstract

Pakistan maintains one of the world's largest livestock inventories with about six million tonnes of annual meat production but captures less than one percent of global meat market. This gap lies in value capture with raw meat being the major exported item as by-product gets wasted with unrealized higher value halal streams. Therefore, this systematic review aimed at proposing reframing Pakistan' halal trade through the lens of circular economy by carrying out a desk-based SWOT-TOWS analysis of halal meat value chain across two operational pillars. The first pillar is of by-product valorisation as Pakistan reports approximately 503,000 tons of edible offal and 84,600 tons of blood each year, along with tens of millions of hides and skins. However, only some portion of hides, skins, and leather is exported, and certified gelatin, collagen, plasma-protein, and pharmaceutical routes are still untapped. These products have high demand globally with multi-billion industries, yet their verified halal supply is scarce leaving a premium export niche unfilled. The second pillar deals with an emergent and understudied concern associated with food packaging made of recycled plastic as animal-derived processing additives, such as tallow-derived stearates and slip agents, bound in the polymer matrix and not removed by washing, along with an unofficial, unsegregated waste stream, can make recycled food packaging non-halal, as the current safety-decontamination regime certifies chemical safety rather than halal status. Both pillars are supported by a shared verification layer in conjunction with certified-halal sourcing.

The SWOT analysis observed a constant asymmetry as advantages based on infrastructure and endowments are bonded by constraints like weak traceability and accreditation, fragmented standards, and lack of packaging standards. These elements were combined using a TOWS matrix to create a turnaround-focused plan that can be operationalized through a coordinated certification process between the Pakistan Halal Authority and PSQCA. An effective circular economy framework that transforms waste, including packaging risk and slaughter by-products, into certified, exportable value was also suggested.

Keywords: Halal Meat Industry; By-product valorization; Recycled food packaging; SWOT; Circular economy

(O-08) BEYOND THE "DOUBTFUL" LABEL: A SOURCE- AND PROCESS-BASED FRAMEWORK FOR HALAL ASSESSMENT OF FOOD ADDITIVES

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Abstract

Background: Food additives whose halal status varies according to source or manufacturing conditions are often broadly classified as "doubtful." However, much of this apparent uncertainty may be resolved when the actual source and relevant production conditions are systematically evaluated.

Objective: This study aimed to develop a practical source- and process-based framework for halal assessment of food additives and to determine the extent to which apparent uncertainty can be resolved through systematic verification.

Methods: A total of 411 EU-authorised food additives were reviewed according to their reported sources, halal-related characteristics, technological functions, and relevant production conditions. Additives were classified as Direct, Conditional, Unresolved, or Prohibited according to whether their halal status could be determined directly or required verification of source, species, or manufacturing process. Conditional assessments were further evaluated according to whether uncertainty was primarily source-dependent or process-dependent.

Results: Of the 411 additives evaluated, 88.08% were classified as Direct, 11.44% as Conditional, 0.24% as Unresolved, and 0.24% as Prohibited. Among additives requiring conditional or unresolved assessment, 72.92% were primarily source-dependent, whereas 25.00% were process-dependent. Additives with an unequivocally permissible source and no identified process-related concern were generally assessed directly. In contrast, additives that could originate from both plant and animal sources required verification of the actual source, while animal-derived additives additionally required confirmation of species and halal status. Microbially produced additives could require assessment of culture media and other production inputs. Emulsifiers, colours, and antioxidants together accounted for 83.3% of additives requiring conditional or unresolved assessment.

Conclusion: Most food additives can be assessed more definitively than suggested by a broad "doubtful" classification. A source- and process-based framework distinguishes genuinely unresolved cases from additives whose halal status becomes clear once specific verification criteria are met. This approach may support more transparent, targeted, and practical halal certification and provide clearer guidance for manufacturers, certifiers, and consumers.

Keywords: halal certification; halal; food additives; doubtful; source verification; production process

(O-09) KRILL OIL AS A HALAL FUNCTIONAL FOOD: NUTRITIONAL POTENTIAL, HEALTH BENEFITS, AND HALAL CONSIDERATIONS

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Abstract

Antarctic Krill oil (AKO) derived from Antarctic krill (Euphausia superba) has emerged as a marine-derived functional ingredient because of its unique nutritional composition. AKO consists of phospholipids, omega-3 polyunsaturated fatty acids, mainly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), triglycerides (TAG), vitamins, minerals, along with astaxanthin, a naturally powerful antioxidant. AKO differs from fish oil in terms of its unique molecular structure, as EPA and DHA are bound to phospholipids instead of TAG (enhancing bioavailability). The unique molecular structure of AKO has been linked to several potential health benefits, including cardiovascular health, cognitive function, lipid metabolism, muscle function, hypertriglyceridemia, and protection against oxidative stress. The potential utilization of AKO in food and nutraceutical products depends on its Halal status. Although krill is generally regarded as a Halal marine source, the AKO Halal status may be affected by the solvents, extraction process, and encapsulation ingredients. Ingredient traceability and Halal assurance practices are important parameters in maintaining the integrity of AKO in the Halal industry for the development of functional and nutraceutical foods. Antarctic krill oil therefore represents a promising opportunity at the intersection of marine nutrition, functional food development, halal quality assurance, and consumer health.

Keywords: Antarctic krill oil, Halal food, omega-3; EPA: DHA, health benefits, astaxanthin

(O-10) QUALITY AND CONFORMITY ASSESSMENT OF A HALAL PLANT-BASED PROTEIN SUPPLEMENT AS AN ALTERNATIVE TO ANIMAL-BASED SUPPLEMENTS

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Abstract

Imported animal-based protein supplements, dominated by whey, are costly and difficult to verify with respect to composition, label accuracy and ingredient provenance, which weakens confidence in the halal supply chain. This study developed a locally sourced plant-based supplement from pumpkin seeds, peas and dates and evaluated it, together with two commercial supplements (M1 and M2), as a conformity-assessment case within the halal quality infrastructure (OIC/SMIIC 1 and OIC/SMIIC 2). A survey of 626 physically active respondents showed that whey accounted for 71.7% of consumption and that 11.8% of users did not know their protein source. Five blends exceeding 20% protein were screened, and the optimal blend (60% pumpkin seeds, 30% peas, 10% dates) was compared with the commercial products using AOAC and ISO methods in a completely randomised design (ANOVA, Duncan's test, $p \leq 0.01$). The plant supplement contained 30.38% protein, 22.38% fat, 6.96% fibre and 38.65% carbohydrate (477.5 kcal/100 g), and higher iron, copper and zinc (1.05, 0.25 and 2.34 mg/100 g) than both commercial products. Lead, aflatoxins, coliforms, Escherichia coli and Salmonella were not detected, and microbial counts were within the reference limits. Both commercial products were consistent with their labels: M1 contained 19.14% protein against 17.7% derived from its label (50 g protein per 283 g serving), and M2 contained 28.08% against a declared 28.2%, while the plant supplement had the highest protein content. The plant supplement was also cheaper per 85 g package (10 versus 15 LYD for M2). A short, single-origin, additive-free plant formulation therefore offers a nutritionally competitive, safe and economically feasible option that reduces reliance on animal-derived imports of uncertain provenance, strengthens halal supply-chain integrity, and supports the local halal economy and sustainable supply chains.

Keywords: halal quality infrastructure; OIC/SMIIC; halal supply chain integrity; label conformity; plant-based protein; pumpkin seeds

1. Introduction

Protein supplements have become a mainstream segment of the food market, driven by interest in fitness and muscle development, and whey protein remains the reference product (Aly et al., 2023; Lee et al., 2024). The consumer, however, has few means of verifying what a package contains. In the online survey carried out for this study in Libya (n = 626 physically active respondents aged 18–24 years), whey-based products accounted for 71.7% of consumption and 11.8% of respondents did not

know which type of protein they used. Where the consumer cannot identify the source of the protein, whether a product is what it claims to be, and whether it is acceptable from a halal perspective, cannot be left to the label alone.

For Muslim consumers, halal compliance is not a single property but a chain of assurances covering the source of every ingredient, processing aids, additives and flavourings, and the integrity of handling from raw material to retail shelf. OIC/SMIIC 1 specifies the general requirements for halal food across the food chain, including sources of ingredients, processing, hygiene and food safety (SMIIC, 2019a). Verification of these requirements rests on the halal quality infrastructure: standardisation (OIC/SMIIC 1 and the product and ingredient standards that complement it, such as OIC/SMIIC 22 for halal edible gelatine, OIC/SMIIC 24 for food additives and OIC/SMIIC 47 for dates for industrial purposes), certification (OIC/SMIIC 2, requirements for bodies providing halal certification), accreditation (OIC/SMIIC 3, requirements for bodies accrediting halal conformity assessment bodies) and testing (OIC/SMIIC 35 for laboratories performing halal testing and OIC/SMIIC 36 for proficiency testing) (SMIIC, 2019a; 2019b; 2019c; 2020a; 2020b; 2020c; 2021a; 2022). Supply-chain requirements for transportation, warehousing and retailing are set out in the OIC/SMIIC 17 series, and halal quality management in OIC/SMIIC 18 (SMIIC, 2020d; 2021b).

Within this framework, laboratory testing serves conformity assessment by producing objective evidence on whether a product meets the compositional, safety and labelling requirements against which it is judged. Two kinds of non-conformity are relevant. The first is technical: the product falls below the minimum composition required by the applicable standard. The second is commercial: the measured composition departs from the declared composition. This is a labelling non-conformity and, in the halal context, it is more than a consumer-protection failure, because a halal claim is only as trustworthy as the label that carries it. A product whose declared protein content cannot be relied upon gives no basis for relying on its declared ingredient origin either, and the damage extends to a halal market that depends on trust.

Supply chains add a further dimension. Imported supplements pass through transport, storage and retail steps over which the local consumer and regulator have little visibility. Their animal-derived components, such as whey, gelatine capsules, enzymes and processing aids used upstream, and flavour and carrier systems, cannot be shown to be halal by composition analysis alone; they require documentary traceability back to the source. A locally produced alternative made from three plant ingredients available on the domestic market shortens the chain, removes the animal-derived inputs of uncertain origin, reduces the number of control points that a certification body must verify under OIC/SMIIC 1, and provides a basis for import substitution and for retaining value in the local halal economy. Plant origin does not by itself make a product halal, since hygiene, freedom from non-halal contamination and traceability remain necessary, but it removes the most difficult category of doubt.

This paper therefore treats a plant-based protein supplement formulated from pumpkin seeds, peas and dates as a case for conformity assessment. The objectives were: (1) to develop and select an optimal plant-based formulation; (2) to evaluate its compositional, amino acid, mineral, microbiological, contaminant and sensory quality against two commercial animal-based supplements; (3) to compare measured values with declared values and with reference standards in order to identify non-conformity; and (4) to discuss the findings in relation to halal quality infrastructure and local halal supply chains. The study is not a halal certification exercise; it provides technical evidence on quality,

safety and label conformity on which a certification body or halal conformity assessment body could build.

2. Materials and Methods

2.1 Consumer survey

An electronic descriptive-analytical questionnaire (Appendix 1) was distributed from 13 to 30 October 2025 to physically active individuals in Libya and returned by 626 respondents aged 18–24 years (76.3% male, 23.7% female). It covered the types of supplements consumed, purpose, quantities, timing, side effects and satisfaction. Reliability was assessed with Cronbach's alpha and was acceptable. The results were used to select the commercial comparison products.

2.2 Materials

Dried Deglet Nour dates (*Phoenix dactylifera*; autumn 2024), peas (*Pisum sativum*; January 2025; grown in the Al-Wadi Al-Hay region from seed imported from Italy) and pumpkin seeds (*Cucurbita maxima*; May–June) were purchased from local markets in Tripoli, Libya, and authenticated by plant taxonomists of the Horticulture Department, Faculty of Agriculture, University of Tripoli. Two commercial whey-based supplements were bought from a dietary-supplement store in Tripoli: M1 (an imported mass-gainer supplement) and M2 (an imported recovery supplement fortified with vitamins C and E). Both were chosen on the basis of the survey and both are intended to increase body weight and muscle mass. The declared protein content, expressed per 100 g, was 17.7% for M1 (50 g per 283 g serving) and 28.2% for M2. Analytical-grade reagents and culture media (Liofilchem, Italy; Condalab, Spain) were used throughout.

2.3 Preparation and formulation of the plant supplement

Peas were dehulled, dates were pitted and pumpkin seeds were cleaned of residues; all were washed, dried at 40 °C for 3–5 days, ground, sieved (250 µm), re-dried at 40–50 °C for 15–20 min and stored in airtight glass containers in a cool, dark, dry place. Pumpkin seeds and peas were the primary protein sources, and dates (10–15% in all blends) served as a natural sweetener, a mineral source and a flavour-masking agent for legume notes. Five blends differing in the proportions of pumpkin seeds (25–70%), peas (15–65%) and dates (10–15%) were screened for colour, odour and ease of solubility and for a calculated protein content of at least 20%. Blends 1 (70:15:15) and 5 (25:65:10) were excluded at the first screening because of a dark colour and lumpy texture and a pronounced legume taste, respectively, and three blends (A, B, C) were retained; B was excluded for a pronounced legume odour, and A was preferred to C on chemical and sensory grounds. The selected blend A (60% pumpkin seeds, 30% peas, 10% dates) was used for all further analyses.

2.4 Analytical methods

Analyses were carried out at the Food and Drug Control Center, Tripoli Branch, and the blends were prepared at the Food Analysis Laboratory, University of Tripoli, between November 2024 and 2025. All determinations were made in triplicate by AOAC (2019) official methods: moisture (925.10), ash (923.03), crude protein by Kjeldahl (923.05; N × 6.25), crude fibre (920.86), fat by Soxhlet extraction (920.85), acid-insoluble ash (941.12) and titratable acidity as oleic acid (940.28). Carbohydrates were calculated by difference and energy with Atwater factors (4, 9 and 4 kcal/g for protein, fat and

carbohydrate). Lead, iron, copper and zinc were determined by flame atomic absorption spectrophotometry (Agilent AA 280) after wet digestion (AOAC 984.27 and 999.11); the working range of the method for lead was 0.01–1 mg/kg, and results below 0.01 mg/kg were reported as not detected (ND). Total aflatoxins were determined by ELISA (RIDASCREEN; AOAC 991.31) after methanol extraction and immunoaffinity clean-up. Aflatoxins were analysed in the plant supplement, its raw ingredients and the two commercial supplements (M1 and M2). Amino acids were estimated by near-infrared spectroscopy (NIR 7200 diode-array system) with calibration models built on reference methods (AOAC 997.06) and expressed as g/100 g.

Total viable count, coliforms, *E. coli*, *Salmonella* and yeasts and moulds were determined according to ISO 4833-1:2013, ISO 4832:2006, ISO 16649-2:2001, ISO 6579-1:2017 and ISO 21527-2:2008, respectively, after homogenising 25 g of sample in 225 mL of 0.1% peptone water.

2.5 Sensory evaluation and economic assessment

Twenty-five untrained panellists (15 males, 10 females; 20–43 years; students and staff of the Faculty of Agriculture and the Food and Drug Control Center) evaluated colour, ease of solubility, texture, taste, odour, aftertaste and overall acceptability on a 9-point hedonic scale (Al-Jadaily and Humaida, 2002). Samples (80 g powder in 500 mL water) were coded with random three-digit numbers and served at room temperature in identical cups. Production cost per 85 g package was estimated from local raw-material prices, packaging, electricity and labour (Arab Organization for Industrial Development, Standardization and Mining, 2021), and compared with the retail prices of M1 and M2.

2.6 Statistical analysis

The experiment followed a completely randomised design (CRD) with three replicates. Data were analysed by one-way analysis of variance in SAS (SAS Institute, 2002), with product as the factor, and means were separated by Duncan's multiple range test (Duncan, 1955) at $p \leq 0.01$. Means sharing a letter within a row are not significantly different. Declared values were taken from the product labels and converted to a per-100 g basis (M1 label: 50 g protein per 283 g serving; M2 label: 28.2 g per 100 g) before comparison with measured values.

3. Results

3.1 Consumer survey

Consumption of protein supplements exceeded 83% among respondents. Whey was the most consumed type (71.7%), followed by creatine (marketed alongside protein products but not a protein), whereas mixed plant proteins (2.1%) and soy (1.0%) were the least used (Table 1). A further 11.8% of respondents did not know which type of protein they used. Muscle-mass gain was the main motive (56.2%). Most respondents took supplements daily (59.4%), usually after exercise (39.4%); 62% reported no side effects and 16% digestive disturbances.

Table 1. Protein supplement types consumed by survey respondents (n = 626).

Supplement type	Frequency	Percentage (%)
Whey protein	449	71.7
Unknown protein type	74	11.8
Egg albumen protein	40	6.4

Beef protein	35	5.6
Mixed plant proteins	13	2.1
Casein protein	9	1.4
Soy protein	6	1.0

3.2 Composition and safety of the plant ingredients

Pumpkin seeds (36.26% protein, 36.91% fat) and peas (28.46% protein) were the protein-bearing components, whereas dates contributed mainly carbohydrate (87.38%) (Table 2). Moisture ranged from 3.34 to 7.73%, and the crude fibre content of pumpkin seeds was 7.10%. Pumpkin seeds were the richest source of iron, copper and zinc, and lead was not detected in any ingredient.

Amino acid estimation showed complementary profiles: peas were rich in lysine (5.68 g/100 g) and leucine (4.77 g/100 g), pumpkin seeds in threonine (3.73), isoleucine (3.82) and cystine (3.94), and dates were a negligible source. Total viable counts ranged from 15 to 230 cfu/g, yeasts and moulds from 6.66 to 13.33 cfu/g, and coliforms, *E. coli* and *Salmonella* were not detected.

Table 2. Composition and safety parameters of the plant ingredients (mean; n = 3).

Parameter	Peas	Dates	Pumpkin seeds	Pooled SE
Moisture (%)	3.34 ± 0.03^{c}	7.73 ± 0.05^{a}	3.74 ± 0.08^{b}	0.05
Ash (%)	3.90 ± 0.04^{a}	2.42 ± 0.02^{c}	3.80 ± 0.003^{b}	0.02
Protein (%)	28.46 ± 0.44^{b}	2.25 ± 0.21^{c}	36.26 ± 1.11^{a}	0.70
Fat (%)	3.24 ± 0.69^{b}	0.22 ± 0.02^{c}	36.91 ± 0.74^{a}	0.58
Carbohydrate (%)	61.06 ± 0.31^{b}	87.38 ± 0.25^{a}	19.29 ± 1.80^{c}	1.07
Crude fibre (%)	6.42 ± 0.06^{b}	2.47 ± 0.15^{c}	7.10 ± 0.14^{a}	0.12
Iron (mg/100 g)	2.00 ± 0.11^{b}	0.20 ± 0.005^{c}	3.37 ± 0.11^{a}	0.09
Copper (mg/100 g)	0.13 ± 0.005^{b}	0.15 ± 0.02^{b}	0.57 ± 0.01^{a}	0.01
Zinc (mg/100 g)	1.08 ± 0.11^{b}	0.17 ± 0.01^{b}	4.32 ± 0.27^{a}	0.16
Lead	ND	ND	ND	–
Total viable count (cfu/g)	230.00 ± 15.27^{a}	15.00 ± 0.00^{c}	186.67 ± 13.33^{b}	11.70
Yeasts and moulds (cfu/g)	13.33 ± 1.66^{a}	6.66 ± 1.66^{b}	11.66 ± 1.66^{ab}	1.66
Coliforms, *E. coli*, *Salmonella*/25 g	ND	ND	ND	–

Means with different letters in a row differ significantly ($p \leq 0.01$). ND, not detected. Values are mean ± standard error (SE) of three replicates; pooled SE is the pooled standard error of the mean. Lead: below the detection limit of 0.01 mg/kg.

3.3 Proximate composition and declared protein

The plant supplement differed significantly from both commercial products in all proximate parameters except moisture, which was similar to M1 (Table 3). Its protein content (30.38%) was the highest, followed by M2 (28.08%) and M1 (19.14%). The plant supplement had markedly higher fat (22.38%), the lowest carbohydrate content (38.65%) and the highest energy value (477.5 kcal/100 g), and it was the only product containing dietary fibre (6.96%).

Measured protein in M1 (19.14%) was higher than the value derived from its label (17.7%, calculated from 50 g protein per 283 g serving), a difference of about 1.4 percentage points, or 8% in relative

terms. Measured protein in M2 (28.08%) was close to its declared value (28.2%).

Table 3. Proximate composition of the plant supplement and the commercial supplements (mean; n = 3).

Parameter	Plant supplement	M1	M2	Pooled SE
Moisture (%)	5.00 ± 0.058[a]	5.01 ± 0.008[a]	4.01 ± 0.005[b]	0.006
Ash (%)	3.47 ± 0.055[a]	1.96 ± 0.008[b]	1.99 ± 0.020[b]	0.034
Protein (%)	30.38 ± 0.170[a]	19.14 ± 0.108[c]	28.08 ± 1.692[b]	0.416
Declared protein (%)	–	17.7*	28.2	–
Fat (%)	22.38 ± 0.678[a]	4.14 ± 0.095[b]	2.59 ± 0.104[c]	0.399
Carbohydrate (%)	38.65 ± 0.497[c]	69.75 ± 0.081[a]	63.27 ± 1.845[b]	1.104
Crude fibre (%)	6.96 ± 0.072[a]	0.00 ± 0.000[b]	0.00 ± 0.000[b]	0.041
Energy (kcal/100 g)	477.5 ± 0.871[a]	392.86 ± 0.457[b]	388.7 ± 0.835[b]	0.74

Means with different letters in a row differ significantly ($p \leq 0.01$). Energy was calculated with Atwater factors from the protein, fat and carbohydrate values shown. Values are mean ± standard error (SE) of three replicates; pooled SE is the pooled standard error of the mean.

*Calculated from the label: 50 g protein per 283 g serving (50 ÷ 283 × 100).

3.4 Amino acid profile

Estimated amino acid contents differed significantly among the three products (Table 4). The plant supplement had the highest leucine (2.49 g/100 g, versus 1.81 for M1 and 1.05 for M2), isoleucine (1.78), lysine (2.29), threonine (1.49) and cystine (1.07). M2 was higher in valine (3.36), glycine, arginine and the aromatic amino acids. Tryptophan (0.13 g/100 g), phenylalanine (0.37) and tyrosine (0.08) were low in the plant supplement, and threonine, methionine, cystine and tryptophan were not detected in M2.

Table 4. Estimated amino acid contents (g/100 g) of the plant supplement and the commercial supplements.

Amino acid	Plant supplement	M1	M2	Pooled SE
Threonine	1.49[a]	1.19[b]	ND[c]	0.014
Valine	1.65[b]	0.78[c]	3.36[a]	0.052
Methionine	0.31[b]	0.49[a]	ND[c]	0.02
Isoleucine	1.78[a]	0.89[c]	1.27[b]	0.007
Leucine	2.49[a]	1.81[b]	1.05[c]	0.016
Phenylalanine	0.37[c]	0.45[b]	1.84[a]	0.017
Lysine	2.29[a]	2.01[b]	0.48[c]	0.015
Histidine	0.70[b]	0.64[b]	1.17[a]	0.02
Tryptophan	0.13[b]	0.54[a]	ND[c]	0.028
Aspartic acid	3.46[a]	2.49[b]	1.59[c]	0.061
Serine	1.99[a]	1.43[b]	0.73[c]	0.037
Glutamic acid	1.79[b]	1.95[ab]	2.38[a]	0.147
Proline	1.46[b]	1.04[c]	1.61[a]	0.016

Glycine	1.35[b]	0.90[c]	2.55[a]	0.043
Alanine	1.35[a]	1.33[a]	1.09[b]	0.031
Cystine	1.07[a]	0.45[b]	ND[c]	0.014
Tyrosine	0.08[c]	0.32[b]	1.34[a]	0.02
Arginine	2.43[b]	1.24[c]	4.29[a]	0.08

Means with different letters in a row differ significantly ($p \leq 0.01$). ND, not detected. Values estimated by NIR spectroscopy. SE, pooled standard error of the mean.

3.5 Minerals, contaminants and microbiological safety

The plant supplement contained more iron (1.05 mg/100 g), copper (0.25 mg/100 g) and zinc (2.34 mg/100 g) than M1 and M2 (0.30 mg iron, no detectable copper and about 0.17 mg zinc per 100 g; Table 5). Lead (below 0.01 mg/kg) and total aflatoxins were not detected in any product. Acidity of the extracted fat was 0.10% (as oleic acid) and acid-insoluble ash 0.032% in the plant supplement.

No coliforms, *E. coli* or *Salmonella* were detected in any of the three products. Total viable count (246.66 cfu/g) and yeasts and moulds (8.33 cfu/g) in the plant supplement were significantly higher than in the commercial products (Table 5).

Table 5. Minerals, contaminants, microbiological and quality indices of the supplements.

Parameter	Plant supplement	M1	M2	Pooled SE
Iron (mg/100 g)	1.05 ± 0.015[a]	0.30 ± 0.012[b]	0.30 ± 0.004[b]	0.011
Copper (mg/100 g)	0.25 ± 0.045[a]	ND[b]	ND[b]	0.026
Zinc (mg/100 g)	2.34 ± 0.271[a]	0.16 ± 0.042[b]	0.17 ± 0.030[b]	0.159
Lead (mg/kg)	ND	ND	ND	–
Total aflatoxins (µg/kg)	ND	ND	ND	–
Acidity, as oleic acid (%)	0.10 ± 0.00[c]	0.20 ± 0.003[a]	0.15 ± 0.012[b]	0.015
Acid-insoluble ash (%)	0.032 ± 0.001[b]	0.038 ± 0.001[a]	0.022 ± 0.001[c]	0.0008
Total viable count (cfu/g)	246.66[a]	48.33[b]	ND[c]	6.596
Yeasts and moulds (cfu/g)	8.33[a]	3.33[b]	ND[c]	1.36
Coliforms, *E. coli*, *Salmonella*/25 g	ND	ND	ND	–

Means with different letters in a row differ significantly ($p \leq 0.01$). ND, not detected. Values are mean ± standard error (SE) of three replicates; pooled SE is the pooled standard error of the mean. Lead: below the detection limit of 0.01 mg/kg.

3.6 Sensory acceptability

Sensory scores differed significantly among the three products for all seven attributes evaluated ($p \leq 0.01$; Table 6). The commercial products scored higher than the plant supplement for colour (M2 8.44, M1 7.04, plant 5.92), ease of solubility (8.36, 7.68, 5.80), texture (8.28, 7.28, 5.92) and odour (8.32, 7.48, 5.84). In taste, the plant supplement (7.48) was rated above M1 (6.44) and below M2 (8.32). The same order was found for aftertaste (plant 7.40, M1 6.16, M2 8.36) and for overall acceptability (plant 7.60, M1 6.68, M2 8.52).

Table 6. Sensory scores (9-point hedonic scale; n = 25).

Attribute	Plant supplement	M1	M2	Pooled SE
Colour	5.92c	7.04b	8.44a	0.214
Ease of solubility	5.80c	7.68b	8.36a	0.175
Texture	5.92c	7.28b	8.28a	0.197
Taste	7.48b	6.44c	8.32a	0.207
Odour	5.84c	7.48b	8.32a	0.178
Aftertaste	7.40b	6.16c	8.36a	0.217
Overall acceptability	7.60b	6.68c	8.52a	0.188

Means with different letters in a row differ significantly ($p \leq 0.01$). SE, pooled standard error of the mean.

3.7 Economic assessment

The raw-material cost of an 85 g package (51 g pumpkin seeds, 25.5 g peas, 8.5 g dates) was 2.35 LYD at local prices (Table 7). With packaging (1.10 LYD) the cost was 3.45 LYD; with electricity and labour (3 LYD) the total cost was 6.45 LYD against a selling price of 10 LYD, giving a margin of 3.55 LYD (35.5% of the selling price). M2 sells at 15 LYD per 85 g and M1 at 280–300 LYD per 2 kg bag (about 11.9–12.8 LYD per 85 g). Per gram of protein, the plant supplement cost about 0.39 LYD (10 LYD for 25.8 g of protein), against about 0.63 LYD for M2 (15 LYD for 23.9 g) and 0.73–0.79 LYD for M1 (11.9–12.8 LYD for 16.3 g), calculated from the measured protein contents.

Table 7. Raw-material cost of one 85 g package of the plant supplement.

Ingredient	Share (%)	Quantity (g)	Price (LYD/kg)	Cost (LYD)
Pumpkin seeds	60	51.0	40	2.040
Peas	30	25.5	10	0.255
Dates	10	8.5	6	0.051
Total	**100**	**85.0**	–	**2.346**

4. Discussion

4.1 Consumer trends and the provenance gap

Muscle-mass gain as the main motive agrees with Teixeira et al. (2022) and López-Martínez et al. (2022). From a halal-assurance viewpoint, the key finding is that animal-based products dominate the market while 11.8% of users could not say what protein they consumed. Neither group can trace the source of the protein, the processing aids or the carriers in the formulation. Plant-based mixed proteins, by contrast, are barely used (2.1%), which indicates both an unmet need for a verifiable alternative and the limited availability of one. Excessive intake of protein supplements carries health risks, and plant-based protein can reduce some of them (Goldman et al., 2024; Lee et al., 2024).

4.2 Quality of the plant ingredients

Moisture of the ingredients was below the 12% limits of Libyan Standards No. 3401/2008 (pumpkin seeds) and No. 423/2001 (peas) and below the 18% limit of the Libyan standard for dried dates for industrial use (2022). Proximate values were within the ranges reported in the literature (Boukid et al., 2021; Wu et al., 2023; Singh and Kumar, 2023; Barakat and Alfheeaid, 2023). The fibre content of pumpkin seeds reflects the use of unhulled seeds. Lead was below the limits of Libyan Standard No.

594/2025 (0.1 mg/kg for peas and 0.5 mg/kg for dates). The complementary amino acid profiles of peas and pumpkin seeds support pairing the two protein sources. The low microbial counts are consistent with the low moisture of the materials and the antimicrobial constituents reported for them (Dotto and Chacha, 2020; Wu et al., 2023), although water activity was not measured.

4.3 Label conformity and proximate composition

The protein content of the plant supplement agreed with the value calculated from the ingredient analyses (about 30.5%), which supports the consistency of the formulation, and M2 agreed with its declared protein content (28.2%). Both commercial products therefore agreed with their labels, and the discrepancy observed for M1 is most plausibly attributable to analytical variation and batch variability. This agreement supports the reliability of declared composition, on which halal assurance depends. As a separate technical point, M1 is below the 20% minimum protein of Egyptian Standard 2730/2007 (Egyptian Organization for Standardization and Quality, 2007) on an as-is basis, although the standard is expressed on a dry-matter basis, where the value would be about 20.2%; values should therefore be reported on both bases. The advantage of the plant supplement lies not in labelling accuracy but in its higher protein content than M1 (30.38% versus 19.14%), its higher iron, copper and zinc, and its lower price. Nevertheless, 11.8% of surveyed consumers did not know the source of their protein, showing that transparent, verifiable ingredient information remains necessary. The results concern the lots analysed and should be confirmed on further batches before general conclusions are drawn about the brands.

The higher fat of the plant supplement is due to the pumpkin seeds (60% of the blend); the fat of pumpkin seeds is reported to be predominantly unsaturated (Singh and Kumar, 2023), although the fatty acid profile was not determined here. Its energy value was above the minimum of 350 kcal/100 g in Egyptian Standard 2730/2007. A 100 g portion would supply about 23–28% of an adult's daily fibre intake of 25–30 g (WHO/FAO/UNU, 2007). The fibre content did not match the fibre provision of Egyptian Standard 2730/2007, whose requirements are written for animal-based products.

4.4 Amino acid profile

The methionine plus cystine content of the plant supplement (1.38 g/100 g) exceeded the adult reference of 1.05 g per 70 kg body weight (WHO/FAO/UNU, 2007). Per 100 g it also met or exceeded the reference values for isoleucine (1.40), lysine (2.10), threonine (1.05) and histidine (0.70) and approached the reference for valine (1.65 versus 1.82); leucine (2.49) was slightly below its reference of 2.73. These references are expressed per day for a 70 kg adult, so the comparison with a 100 g portion is indicative only. Leucine is the main trigger of muscle protein synthesis, and plant-protein blends may stimulate it comparably to whey when the leucine threshold is reached (Paddon-Jones et al., 2004; Van Vliet et al., 2015; Pinckaers et al., 2021; Teixeira et al., 2022).

Two limitations must be stated. First, tryptophan (0.13 g/100 g), phenylalanine (0.37) and tyrosine (0.08) were low in the plant supplement and below the adult reference values, and tryptophan and the aromatic amino acids are the likely limiting amino acids of the formulation. Their values were also much lower than those expected from the ingredients (e.g., tyrosine 0.95 and 0.74 g/100 g in pumpkin seeds and peas), which loss during mild drying at 40–50 °C is unlikely to explain (cf. Zhang et al., 2021). Second, amino acids were estimated by NIR, which depends on the calibration matrix. The non-detection of threonine, methionine, cystine and tryptophan in M2, a whey-based product, is

biochemically implausible and suggests that the calibration does not transfer reliably between plant and dairy matrices. The cross-product comparison in Table 4 should therefore be regarded as indicative and confirmed by a reference chromatographic method, and protein digestibility (e.g., PDCAAS) should also be assessed.

4.5 Minerals, contaminants and microbiological safety

The higher iron, copper and zinc of the plant supplement reflect the contribution of pumpkin seeds and peas. A 100 g portion supplies about 11.5% of a 9.1 mg/day iron reference (WHO/FAO, 2004); the absorption of this non-haem iron was not examined, and the legume phytate content may reduce it. The iron content of the blend was also lower than the value expected from the ingredient analyses (about 2.6 mg/100 g by weighted calculation), so it should be re-determined on further batches. The absence of lead and aflatoxins was in compliance with the 3 mg/kg lead limit for protein supplements in Libyan Standard No. 594/2025 and with the 10 µg/kg aflatoxin limit applied in this study. Acidity of the extracted fat and acid-insoluble ash were within the limits of 0.2% and 0.08% of Egyptian Standard 2730/2007, which indicates fresh, clean raw materials and no rancidity.

The microbial counts of the plant supplement were within the limits of Egyptian Standard 2730/2007 (10^3 cfu/g and 10 cfu/g) and the Codex values applied by the authors (CAC, 2015). The yeast and mould count is close to its limit. Because the ingredients were dried at only 40–50 °C, which is not a lethal treatment, the microbiological stability of the product relies entirely on raw-material quality and low moisture; a validated microbial-reduction step and water-activity monitoring should be introduced before commercial production, and are in any case required by the hygiene provisions of OIC/SMIIC 1.

4.6 Sensory acceptability

The higher scores of the commercial products for colour, solubility, texture and odour are expected from a whole-seed powder with higher fibre and fat content, no added emulsifiers or thickeners, and the lower solubility of plant proteins. A bitter aftertaste was noted in M1. The overall acceptability of the plant supplement (7.60) placed it within the very good band (6–7) of the scoring scale used. Solubility, colour and odour are therefore the main weaknesses to be addressed, for example by finer milling or by a permitted natural emulsifier such as lecithin, provided that its source is declared and verified as halal.

4.7 Economic feasibility

The plant supplement was the least expensive of the three while providing 30.38% protein. Production from domestic raw materials keeps value within the local economy and reduces exposure to import and currency risk. Prices reflect the market at the time of the study, and a full cash-flow and break-even analysis is still required.

4.8 Implications for halal quality infrastructure and supply-chain integrity

The findings bear on three elements of the halal quality infrastructure. First, on **standardisation (OIC/SMIIC 1)**: the formulation contains three single-origin plant ingredients and no gelatine, whey, enzymes, flavour carriers or other additives, so the sources that OIC/SMIIC 1 requires to be established are limited to three plant materials and their handling. Animal-derived inputs, by contrast, require a verified chain back to the origin, including the status of the animal and the processing aids

used, which neither the consumer nor the local regulator can check for an imported product on the basis of laboratory composition alone. Where additives would be needed to improve solubility or colour, OIC/SMIIC 24 provides the reference for their evaluation.

Second, on certification and testing (OIC/SMIIC 2, 3, 35 and 36): a certification body operating under OIC/SMIIC 2 needs objective evidence on composition, contaminants and label accuracy. This study shows how such evidence can be generated for a plant-based product, and the label-conformity check applied to M1 and M2 shows what it can reveal for imported products. To carry weight in a halal certification decision, the testing should be performed by laboratories whose competence is recognised under OIC/SMIIC 35 and ISO/IEC 17025 and that take part in proficiency testing (OIC/SMIIC 36). Third, on supply-chain integrity (OIC/SMIIC 17 and 18): a short, local chain with a small number of suppliers is simpler to control for transport, storage and retail than a long import chain, and the safety and compositional data reported here can form the basis of a halal quality management system under OIC/SMIIC 18. Both commercial products agreed with their declared protein content, and the check illustrates why halal assurance and label truthfulness cannot be separated: a product whose label proved inaccurate would undermine trust in every other claim made on the pack.

4.9 Limitations

The main limitations are: halal certification itself was not carried out, and the halal status of M1 and M2 (including any halal certification on their packs) was not assessed; amino acids were estimated by NIR and require confirmation; fatty acid profile, protein digestibility, mineral bioavailability, anti-nutritional factors and shelf life were not determined; only two commercial products, one lot each, were analysed; the sensory panel was small and untrained, and because the same panellists rated all three products a randomised-block analysis by panellist would be more appropriate than the CRD used; and the analytical replicates were drawn from a single lot of each product. The results should be read as a technical basis for further work and not as a claim of nutritional or halal superiority.

5. Conclusion.

A locally sourced plant-based protein supplement (60% pumpkin seeds, 30% peas, 10% dates) contained 30.38% protein, 22.38% fat, 6.96% fibre and 38.65% carbohydrate (477.5 kcal/100 g), more iron, copper and zinc than the two commercial whey-based products, and no detectable lead, aflatoxins or pathogens. It was also the cheapest of the three per package. Its main weaknesses are low tryptophan and aromatic amino acid contents, lower solubility and colour acceptability, and a microbial load that depends on raw-material quality because no lethal step is applied. Both commercial products conformed to their declared protein content (M1 19.14% against 17.7% calculated from its label; M2 28.08% against 28.2%), so the advantage of the plant supplement lies in its higher protein and mineral content and lower price rather than in label accuracy**.**

By shortening the supply chain, removing animal-derived inputs of uncertain provenance and providing objective evidence on composition and label accuracy, the plant formulation supports halal supply-chain integrity and the local halal economy. We recommend that (1) the formulation be taken forward to halal certification under OIC/SMIIC 1 and OIC/SMIIC 2 with testing by laboratories operating under OIC/SMIIC 35; (2) a microbial-reduction step, water-activity control and improved milling be introduced; (3) amino acids, fatty acids and digestibility be confirmed by reference

methods; (4) regulators run routine label-conformity surveillance of imported supplements; and (5) Libya adopt a national standard for protein-rich dietary supplements with specific limits for composition, contaminants and microbiology.

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(O-11) FROM WASTE TO WELLNESS: TRANSFORMING HALAL FOOD BY-PRODUCTS INTO SUSTAINABLE NUTRITION FOR HUMAN HEALTH

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Abstract

Although food processing by-products are increasingly recognized as important sources of nutrients and bioactive substances, significant amounts are discarded, causing losses in nutrition, the environment, and the economy. This study examined the potential of certain halal food processing by-products to recover nutritious substances and use them in developing functional foods. The proximate composition, dietary fibre, antioxidant activity, and functional qualities of citrus fruit peels were assessed. Model functional food formulations were developed by processing citrus peels, cereal fractions and dairy whey as by-product ingredients through extraction, drying, and stabilization methods to develop nutritional food by-product bars. The findings showed that significant levels of protein, dietary fibre, minerals, and antioxidant chemicals were present in this nutritional bars. These ingredients usability and potential for inclusion into food compositions were enhanced by recovery and stabilization. When compared to their corresponding control goods, optimized formulations demonstrated better nutritional qualities, such as more dietary fibre and antioxidant capacity. Moderate absorption levels preserved adequate color, flavor, texture, and overall acceptability, according to sensory examination. On a 9-point hedonic scale, the optimized formulations overall sensory appeal was above 7, indicating their potential for consumer-focused product development ($P<0.05$). The study also found that throughout the value chain, controlled sourcing, raw material traceability, processing aid verification, sanitary processing, and proper storage are necessary to preserve halal integrity by 90%. Therefore, low-value wastes can be turned into useful food ingredients while cutting waste and increasing resource efficiency through the nutritional valorization of halal food by-products. The results show that waste-to-nutrition approaches can promote halal purity, environmental sustainability, human health, and economic value creation all at once. A workable route toward a circular and sustainable halal economy is provided by combining food by-product valuation with halal food innovation, opening doors for the food industry, farmers, small businesses, and academic institutions.

Keywords: Waste, By-products, Halal foods, Sustainable nutrition, Human health

(O-12) WHEN “ALCOHOL-FREE” DOES NOT MEAN “ZERO ALCOHOL”: TECHNOLOGICAL, REGULATORY AND HALAL STANDARDIZATION CHALLENGES

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Abstract

The rapid growth of the market for beverages marketed as “alcohol-free” has brought increasing attention to an issue situated at the intersection of food technology, labeling regulation, consumer protection, and Halal standardization. The central problem addressed in this paper is the potential discrepancy between the regulatory or commercial meaning of the term “alcohol-free” and the consumer expectation that such products contain no alcohol at all.

The aim of this study is to provide an interdisciplinary analysis of the nature and production processes of non-alcoholic beverages, with particular emphasis on non-alcoholic beer, and to examine the criteria that should be considered when assessing such products from a Halal perspective. The methodology is based on a review of relevant technical and scientific literature, a comparative examination of regulatory approaches to labeling, and an analysis of fundamental principles applied in Halal assessment and certification.

The analysis demonstrates that residual ethanol content may depend on the production technology employed, including controlled fermentation, the use of low-ethanol-producing yeasts, and post-fermentation alcohol-removal technologies such as vacuum distillation and membrane filtration. Consequently, the assessment of a product intended for Halal consumers should not rely exclusively on the wording appearing on the label. It should also consider the source and nature of the ethanol, the production process, processing aids and additives, the possibility of cross-contamination, and appropriate analytical verification.

The paper argues that transparency, traceability, and clearly defined certification criteria are essential for maintaining consumer confidence and protecting the integrity of Halal certification. It therefore advocates an integrated approach involving food technologists, Islamic scholars, analytical laboratories, regulatory authorities, and Halal standardization bodies.

Keywords: alcohol-free beverages; ethanol; non-alcoholic beer; labeling; food technology; Halal standardization; Halal certification; consumer protection; transparency.

1. INTRODUCTION

1.1. The Problem of Beverages Declared “Alcohol-Free”

In the contemporary beverage industry, a category of products marketed under the designation “alcohol-free” is gaining an increasingly visible place. Beer, wine and sparkling beverages that imitate

the characteristics of champagne are offered in variants that, in taste, aroma, appearance and presentation, seek to retain the features of traditional alcoholic products, while their ethanol content has been reduced or limited during production. Technological progress, however, has brought to light a problem that concerns not only the chemical composition of these products but also the way in which they are classified and presented on the market. The expression “alcohol-free”, when used on a label, may create the impression that the product contains no ethanol whatsoever. In reality, this terminology does not necessarily constitute evidence of its complete absence.[1] Studies on dealcoholisation technologies show that the removal of ethanol from a fermented beverage is a complex process in which the organoleptic quality of the product must be preserved at the same time. Thermal and membrane-based methods can substantially reduce alcohol content, but the final result depends on the technology employed and the process parameters.[2] It is precisely here that the distinction emerges between the linguistic meaning of the expression “alcohol-free” and its technical and legal definition. In some jurisdictions, this designation may also be used for beverages containing limited amounts of ethanol, provided that the legal criteria for the relevant category are met. Consequently, a lawful commercial declaration is not necessarily equivalent to the absolute absence of the substance. In this context, the presence of ethanol raises questions that require a broader treatment than the mere determination of its concentration. The source of the substance, the manner of its formation, the purpose of its use, the nature of the starting product and the technological processes applied are all elements that may bear on its assessment under Islamic jurisprudence and halal certification standards. For this reason, the examination of beverages declared “alcohol-free” requires the integration of three fields of knowledge: food science and technology, the law governing consumer information, and Islamic jurisprudence. Each addresses a different dimension of the same issue, yet none can fully replace the others. Chemical analysis can determine ethanol content; legislation sets out the conditions of marketing and the labelling obligations; while Islamic jurisprudence and the relevant standards examine the permissibility of the product according to religious criteria. In this sense, the fundamental question is not only whether a beverage contains ethanol, but also whether its trade name intelligibly reflects its actual composition, and whether this information is sufficient for a responsible halal assessment. The study seeks to address this problem from an interdisciplinary perspective, analysing the relationship between production processes, ethanol content, labelling requirements and certification criteria.

2. RESEARCH PROBLEM AND METHODOLOGICAL FRAMEWORK

2.1. Definition of the Research Problem

The use of the expression “alcohol-free” in beverage labelling raises an issue that extends beyond commercial terminology. It raises questions concerning the accuracy of information, the permissible limits of ethanol content and the criteria on which the classification of food products is based. At the core of this problem lies the distinction between the manufacturer’s declaration and the verifiable characteristics of the product. Whereas labelling represents the information communicated to the consumer, laboratory analysis makes it possible to determine chemical composition, including the presence of ethanol at low concentrations. Nevertheless, the laboratory identification of a substance does not in itself establish whether a commercial declaration is lawful. Such a conclusion requires an examination of the provisions governing the relevant product category, the manner in which alcohol

content is expressed and the applicable tolerances. In the European Union, Regulation (EU) No 1169/2011 lays down the general principles for the provision of food information to consumers. Article 7 requires that food information shall not be misleading, while Article 9 and the related provisions of the Regulation set out the mandatory particulars.[3] However, this Regulation does not establish a single, general definition applicable to all categories of beverages designated "alcohol-free". For this reason, assessing the lawfulness of labelling requires an examination of specific provisions and of national legislation.

A further dimension of the problem relates to halal standardisation. In this field, compliance with the legal requirements for marketing does not automatically constitute evidence of religious acceptability. The assessment may require an examination of raw materials, processing aids, the origin of the ethanol and the production processes. Accordingly, the research problem may be summarised in one fundamental question: to what extent is the information declared on the labels of "alcohol-free" beverages sufficient to determine their actual composition and their compliance with halal certification requirements?

2.2. Aim and Objectives of the Study

The aim of this paper is to analyse the relationship between production technology, ethanol content, legal labelling requirements and halal assessment criteria. The study seeks to identify the elements that should be taken into account when examining these products, distinguishing scientific evidence from legal interpretation and religious decisionmaking. To achieve this aim, the following objectives are set:

1.To identify the main technological processes used in the production of beverages with reduced ethanol content. 2.To examine the analytical methods for the determination of ethanol and the significance of laboratory results for the verification of commercial declarations. 3.To compare the legal provisions governing the use of the expression "alcohol-free" in selected jurisdictions. 4.To analyse the relevant principles of Islamic jurisprudence concerning intoxicating beverages, fermentation and the origin of ethanol. 5.To define the technical and documentary criteria that can support a transparent halal certification process.

2.3. Research Questions

To guide the analysis, the study is based on four research questions. **First question:** Does the declaration "alcohol-free" imply the absolute absence of ethanol, or may this designation also be permitted in the presence of limited concentrations of it? **Second question:** What effect do fermentation methods, dealcoholisation technologies and storage conditions have on the final composition of beverages? **Third question:** How do differences between national legislations affect the interpretation of commercial declarations and the protection of the consumer's right to accurate information? **Fourth question:** What scientific, technological and juridical-religious criteria should be applied to assess the compliance of these products with halal standards? The answers are constructed on a comparative analysis of the sources, avoiding generalisations not supported by verifiable data.

2.4. Methodological Approach

The paper is based on a qualitative review of the scientific literature, combined with comparative legal analysis and the normative interpretation of the principles of Islamic jurisprudence. This approach

makes it possible to address a problem that cannot be explained through a single scientific discipline. The technological part examines scientific publications on fermentation, ethanol-removal methods, product stability and laboratory analytical techniques. Priority is given to articles published in peer-reviewed journals, particularly studies that clearly describe their methods and limitations. The OIC/SMIIC 1:2019 standard constitutes one of the reference documents of this study; however, the interpretation of its requirements must rest on the authentic text and on its specific scope of application.[4] The analysis focuses on comparing findings and on identifying the points at which technological, legal and religious criteria intersect or diverge.

2.5. Scope and Nature of the Study

This paper is a review and analytical study. It does not involve market sampling, original laboratory measurements or experiments on the products of specific manufacturers. For this reason, the study does not seek to determine whether any particular brand has accurately declared its alcohol content, nor to draw conclusions about its compliance with halal standards in the absence of the relevant documentation. A further limitation concerns the differences between legal systems and between the approaches of certification bodies. The value of the study lies in constructing a reasoned assessment framework that may serve as a basis for further laboratory research, the improvement of audit procedures and the development of institutional guidelines for halal certification.

3. THE CONCEPT OF ALCOHOL IN ISLAM

The Arabic word khamr (خَمْر) derives from the verbal root khamara, which in Arabic means ‘to cover’, ‘to veil’ or ‘to obscure’. From the same root comes the word khimār, a headscarf or veil, precisely because it covers a woman’s hair. The semantic connection is significant: just as the veil covers the hair, khamr ‘covers’ the mind, clouds it and deprives it of its capacity to discern and to judge soundly.[5] This linguistic sense of khamr, as something that covers the mind, also forms the basis of its legal meaning, which is constructed upon the evidence from the Qur’an and the Sunnah discussed below.

3.1. Evidence from the Qur’an

O you who believe! Wine (khamr), games of chance, idols (stone altars) and divining arrows are but an abomination of Satan’s handiwork; so shun it, that you may prosper![6]

The linguistic structure of this verse is masterful and merits particular attention:

- Order of mention: khamr is listed first among the four prohibited things, before games of chance, idols and divining arrows, which some exegetes read as an indication of the particular importance attached to this matter.

- The word *‘rijs’* (رِجْس): this word denotes impurity (najis) and not merely ‘something bad’ in a general sense; for this reason, the majority of jurists have regarded khamr as physically impure.

- The word *‘fajtanibūhu’* (فَٱجْتَنِبُوهُ, ‘so shun it’): this verbal form in Arabic does not simply mean ‘do not do it’, but ‘keep entirely away from it’, a far stronger formulation than the mere prohibition of a single act. This grammatical form has served as the basis for the principle of sadd al-dharāʾiʿ (blocking the means that lead to what is forbidden).

The Qur'an itself explains the reason for the prohibition in the verse that immediately follows:

"Satan seeks only to sow enmity and hatred among you through wine and games of chance, and to turn you away from the remembrance of Allah and from prayer. Will you not, then, desist?"[7]

This verse identifies two categories of harm, one social and the other spiritual, which operate simultaneously:

Social harm: enmity and hatred among people. Pre-Islamic Arab history was replete with examples of conflicts, and even tribal wars, that had begun as simple quarrels during drinking sessions. This pattern of alcohol-induced social violence is also confirmed by contemporary statistics, in which cases of rape, domestic violence and other crimes are strongly associated with alcohol consumption.

Spiritual harm: being turned away from the remembrance of Allah and from prayer. This is perhaps the most significant consequence from a religious perspective: intoxication harms not only the body or society, but the very direct relationship of the believer with the Creator.

3.2. Hadiths on Alcohol

The Prophetic tradition contains a number of hadiths that broaden and clarify the basic principle. One of the most significant is:

"Whatever intoxicates in large quantities, a small quantity of it is also forbidden (ḥarām)."[8] This hadith is the foundation of one of the most important principles of uṣūl al-fiqh concerning khamr, namely the principle 'Mā askara kathīruhu fa-qalīluhu ḥarām' (That of which a large amount intoxicates, a small amount is also forbidden). The practical formula derived from it is simple yet fundamental: what is measured is not whether the particular glass someone is drinking will intoxicate THAT person; what is measured is whether the SUBSTANCE itself, consumed in normal quantity by an average person, would cause intoxication.

This juridical formula has decisive practical consequences: a person cannot say 'I drink only one small glass, which does not intoxicate me personally' and regard it as permissible. If the substance itself, that is, a larger quantity of it, would intoxicate an average person, then even the smallest quantity of it remains forbidden for every person, regardless of individual tolerance or body weight. This differs fundamentally from the logic of 'responsible consumption' or 'moderate drinking' frequently heard in contemporary discourse outside religious frameworks.

One of the most frequently cited hadiths in the whole of Islamic jurisprudence is the following:

"The lawful is clear and the unlawful is clear, and between them are doubtful matters (mushtabihāt) of which many people have no knowledge. Whoever guards against doubtful matters has safeguarded his religion and his honour; and whoever falls into doubtful matters has fallen into the unlawful, like the shepherd who grazes his flock around a protected sanctuary, on the verge of entering it."[9] This hadith constructs a map with three zones: (1) the clearly lawful (ḥalāl), (2) the clearly unlawful (ḥarām), and (3) an intermediate, unclear zone, shubha (doubt), which calls for particular caution. According to this map, the scholar cannot be content merely with identifying the extremes (pure wine = ḥarām; pure water = ḥalāl); he must develop precise criteria for dealing with the grey zone, to which, as we shall see, most modern food products containing ethanol belong.

It is important to emphasise that shubha does not mean 'automatically ḥarām out of excessive caution'.

The hadith itself states that this zone is one ‘of which many people have no knowledge’, which implies that, through knowledge and study, a person may accurately identify the true status of a given matter and move it out of the zone of uncertainty towards clarity (whether towards the lawful or the unlawful). This is precisely the task of contemporary applied fiqh: by using modern scientific tools (the precise measurement of ethanol percentage and knowledge of the chemical processes of production), scholars today can move many cases from the zone of shubha towards clarity, whether towards the lawful or towards the unlawful.

4. PRODUCTION TECHNOLOGIES OF “ALCOHOL-FREE” BEVERAGES AND FACTORS AFFECTING THE PRESENCE OF ETHANOL

4.1. Formation of Ethanol during Fermentation

Alcoholic fermentation is a biochemical process in which microorganisms, mainly yeasts, convert fermentable sugars into ethanol, carbon dioxide and other metabolic products. This process constitutes the technological basis of traditional beer and wine production, and its control is of particular importance in the development of variants with reduced alcohol content. In beer production, the principal raw material is wort obtained from malt, which contains sugars formed during the enzymatic breakdown of starch. Under suitable conditions, yeasts of the genus *Saccharomyces* metabolise these sugars, forming ethanol and other compounds that influence the characteristics of the beverage. In wine production, the process relies on the fermentation of the sugars present in grape must.

The overall reaction of alcoholic fermentation can be represented by the following equation (Figure 1):

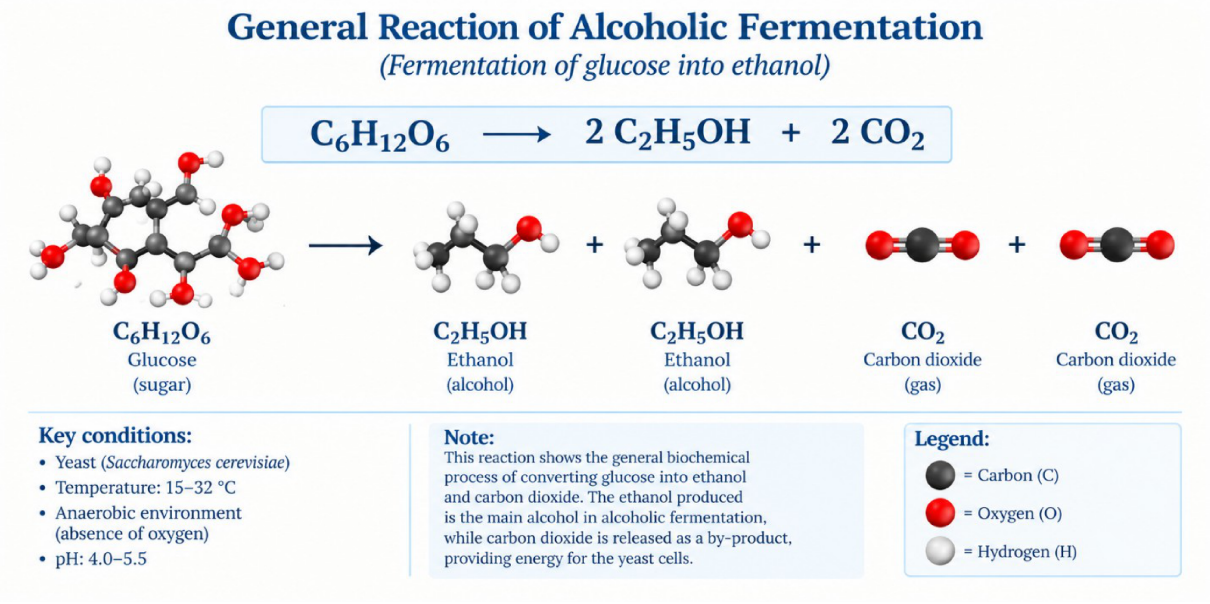

Figure 1. General reaction of alcoholic fermentation (conversion of glucose into ethanol and carbon dioxide)

This equation represents the conversion of glucose into ethanol and carbon dioxide, but it does not include all the metabolic reactions that take place during fermentation. In practice, organic acids, esters, aldehydes and other compounds that influence the aroma and taste of the product are also

formed.

The amount of ethanol produced depends on the composition of the raw material, the sugar concentration, the yeast strain, the temperature, the duration of fermentation and other process conditions. According to Brányik and co-workers, low-alcohol beer can be produced through two basic strategies: limiting the formation of ethanol during fermentation, or removing it from the product after fermentation.[10] This classification is important because it shows that products with similar ethanol content may have undergone fundamentally different technological processes.

4.2. Limiting Ethanol Formation through Biological Methods

Biological methods aim to control fermentative activity so that ethanol production remains at low levels. Unlike dealcoholisation techniques, which intervene after the ethanol has been formed, these methods act upon the conditions that determine its formation. One of the approaches used is interrupted (arrested) fermentation, in which the process is stopped before the yeasts convert a considerable proportion of the sugars into ethanol. The interruption may be achieved by changing the temperature or by other technological procedures that limit microbiological activity. Another method is low-temperature fermentation, known in the technological literature as the *cold contact process*. In this case, the process conditions restrict fermentative metabolism, allowing certain aromatic characteristics to develop without producing large quantities of ethanol. Limiting fermentation, however, also presents technological difficulties. If a considerable proportion of the sugars remains unutilised, the product may have a sweeter taste, different aromatic characteristics and greater susceptibility to microbial growth during storage. Piornos and co-workers, in their review of the aroma chemistry and sensory characteristics of alcohol-free beers, emphasise that the production strategy directly influences the profile of aroma compounds.[11] From the standpoint of halal assessment, biological methods require documentation of the raw materials, microbial cultures and fermentation conditions. Nevertheless, the fact that ethanol formation has been limited does not in itself constitute sufficient evidence of the religious permissibility of the product.

4.3. Dealcoholisation through Physical Processes

Dealcoholisation is the technological process by which ethanol is partially or almost entirely removed from a beverage that contains it.

The food industry employs a variety of physical methods, which rely on the principles of evaporation, mass transfer and the selective separation of components. Unlike restricted fermentation, these technologies may be applied to beverages that have first undergone the usual process of alcoholic fermentation. Mangindaan, Khoiruddin and Wenten classify dealcoholisation technologies into thermal processes, membrane methods and other separation techniques, emphasising the importance of preserving organoleptic qualities during the removal of ethanol.[12]

4.3.1. Vacuum Distillation

Vacuum distillation relies on reduced pressure, which allows volatile components to evaporate at lower temperatures than those required at atmospheric pressure. This method is used to reduce ethanol content while at the same time seeking to limit thermal damage to the product. During distillation, however, other volatile substances that contribute to the characteristic aroma of the beverage may also be removed. For this reason, some industrial processes include the recovery and reintroduction of

aroma compounds. The efficiency of ethanol removal depends on the equipment parameters, temperature, pressure, treatment duration and the initial composition of the product. Therefore, the use of vacuum distillation should not be interpreted as an automatic guarantee that the final ethanol content is zero.

4.3.2. Membrane Filtration Technologies

Membrane processes use semi-permeable barriers to separate particular components of a beverage according to their physical and chemical characteristics. The technologies used for dealcoholisation include reverse osmosis and dialysis, while the literature also discusses other methods of selective transport through membranes. The advantage of these processes lies in the possibility of reducing ethanol under conditions that can limit the thermal exposure of the product. Separation, however, is not always fully selective. Alongside ethanol, other low-molecular-weight compounds that influence the aroma, taste and chemical balance of the beverage may also be removed. The scientific literature regards membrane technologies as an important direction in the development of dealcoholisation processes, but stresses that preserving sensory quality remains a technological challenge.[13]

4.3.3. Effect of Dealcoholisation on Product Composition

The removal of ethanol does not represent merely a quantitative change in alcohol content. It may also affect the balance of the other components of the beverage. Ethanol interacts with aroma substances and influences the perception of taste, mouthfeel and the overall characteristics of the product. For this reason, manufacturers may employ further procedures to correct the organoleptic profile, including the reintroduction of recovered aromas or adjustments to the formulation. From the perspective of halal certification, these interventions require particular scrutiny, because ingredients added after dealcoholisation may differ in origin and characteristics from the starting materials. In such cases, production documentation must make it possible to identify the substances used throughout the entire process, and not merely to determine the ethanol content of the final product.

4.4. Presence of Residual Ethanol in the Final Product

One of the fundamental issues in the production of “alcohol-free” beverages is the possible presence of residual ethanol. In technological terminology, residual ethanol refers to the amount of the substance that remains present after the completion of the production process or after treatment for alcohol removal. Its content is usually expressed as a percentage by volume (% vol.), known internationally as *Alcohol by Volume* (ABV). For example, a content of 0.5% vol. corresponds to an amount of ethanol equivalent to 0.5 millilitres of pure ethanol per 100 millilitres of beverage, in accordance with the definition of percentage by volume at the relevant reference temperature. However, the declared value does not in itself indicate how the ethanol was formed or whether the product initially underwent full fermentation. From an analytical standpoint, a distinction must be drawn between the non-detection of ethanol and proof of its absolute absence. Every laboratory method has specific limits of detection and quantification. For this reason, a result of “not detected” must be interpreted in relation to the sensitivity of the method used. This issue becomes particularly important when products are declared “0.0%”, because interpreting such a figure requires knowledge of the rules on labelling, rounding and measurement accuracy.

4.5. Effect of Storage and Microbiological Stability

The ethanol content at the moment production is completed is not necessarily constant throughout the entire marketing period. In products containing fermentable sugars, the presence of active microorganisms may create conditions for the continuation or resumption of fermentation, particularly where stabilisation processes have been insufficient. Storage temperature, microbiological quality, product composition and packaging integrity are factors that may affect its stability.

Pasteurisation, sterile filtration and other microbiological control procedures are used to limit the activity of microorganisms and to preserve the characteristics of the product throughout its shelf life. However, the effect of storage conditions cannot be generalised to all beverages. It must be assessed on the basis of the formulation, the production technology and the results of stability testing. For quality-control purposes, analysing ethanol at a single point in production may be insufficient where there is a risk of further fermentation. In such cases, verification may be extended to different stages of the product's shelf life.

5. THE LEGAL FRAMEWORK FOR LABELLING "ALCOHOL-FREE" BEVERAGES AND CONSUMER PROTECTION

Legislation on the labelling of "alcohol-free" products does not always fully reflect the requirements of ethics, transparency and consumer protection, since in some cases it appears to give precedence to commercial interests and industry practices. In this context, the differences between the European Union, other comparative jurisdictions and North Macedonia highlight the potential tension between what may lawfully be declared and what the consumer actually understands from the label.

5.1. The Legal Meaning of the Expression "Alcohol-Free"

The legal definition of a food product does not necessarily rest on the ordinary meaning of its name. In regulatory practice, the terms used to classify beverages may carry a specific normative content linked to ethanol concentration, product category and conditions of marketing. The expression "alcohol-free" is a clear example of this distinction. In its linguistic sense, it may imply the complete absence of alcohol. In some legal systems, however, its use is also permitted for products containing limited amounts of ethanol. Consequently, the interpretation of this designation requires identifying the relevant legal provision or guidance, determining the category of the beverage and verifying the applicable alcohol-content limit. An important distinction must be drawn between the expressions "alcohol-free", "low-alcohol", "dealcoholised" and "0.0% alcohol". These designations may carry different technological and legal meanings. For example, dealcoholisation describes an intervention in the production process, whereas the declaration "0.0%" conveys quantitative information whose interpretation depends on the applicable requirements for measurement and labelling. In this respect, one of the fundamental problems is the absence of a unified international definition for all beverages declared "alcohol-free". Comparative documents of regulatory institutions show that different states use different thresholds and classifications.[14] This situation may create difficulties in international trade, particularly when a product manufactured in accordance with the requirements of one state is marketed in a jurisdiction with different rules. For halal certification bodies, this distinction is of direct importance: the lawfulness of using a trade designation cannot, without further examination, be regarded as evidence of compliance with religious requirements.

5.2. The Regulatory Framework of the European Union

European Union legislation treats consumer information as an essential element in the functioning of the food market. The principal act in this field is Regulation (EU) No 1169/2011, which lays down the general requirements for the information provided to consumers concerning food products.[15] Article 7 of this Regulation provides that food information shall not be misleading, particularly as regards the characteristics, nature, identity, composition and properties of the product. This principle is of particular importance for beverages labelled “alcohol-free”, since the declaration must be assessed not only formally but also in relation to the impression it creates on the consumer. Article 28 and Annex XII of the Regulation deal with the indication of alcoholic strength. For beverages containing more than 1.2% alcohol by volume, with the exception of categories subject to specific provisions, the alcohol content must be indicated in accordance with the relevant requirements. However, the 1.2% threshold does not constitute a general definition of the expression “alcoholfree”. It relates to the obligation to indicate alcoholic strength and must not be interpreted as an authorisation to market every beverage below this level under the designation “alcohol-free”.

5.2.1. Specific Rules for Dealcoholised Wine

An important development in European legislation was the adoption of Regulation (EU) 2021/2117, which amended, among other things, provisions on the common organisation of agricultural markets and introduced specific rules for wine products that undergo dealcoholisation.[16] Within the framework of these provisions, a distinction is drawn between dealcoholised and partially dealcoholised products.

For the relevant wine categories, the term “dealcoholised” refers to products whose actual alcoholic strength does not exceed 0.5% by volume. The term “partially dealcoholised”, by contrast, is used under specific conditions for products that have undergone the relevant process but retain a higher alcohol content. Nevertheless, the legal definition of dealcoholised wine must not be confused with an assessment of religious permissibility. A product may be lawfully classified under European legislation, while halal certification may require further examination of its origin and production process.

5.3. Differences between National Approaches

The absence of a universal definition of the expression “alcohol-free” is also evident when national practices are compared. A telling example is the United Kingdom, where guidance issued by the Department of Health and Social Care in 2018 recommends the use of the expression “alcohol-free” for relevant products with an alcohol content not exceeding 0.05% by volume.[17] The same guidance distinguishes this category from dealcoholised beverages with a content of up to 0.5% and from low-alcohol products. These definitions, however, are advisory in nature and should not be presented as general, legally binding provisions for every category of beverage. In the 2023 public consultation document, the British authorities examined the possibility of changing the recommended threshold for the designation “alcohol-free” from 0.05% to 0.5%. This initiative was based on market developments and on the need to assess whether the existing terminology provides consumers with sufficient and comprehensible information.[18] From the standpoint of halal standardisation, national differences create a particular challenge: a product may be lawfully marketed under the same designation in two states, even though the requirements underlying that designation are not identical. This makes independent verification of the technical documentation and of the product’s composition indispensable during

certification procedures.

5.4. Legal Liability of Manufacturers and Food Business Operators

Responsibility for the accuracy of food information is one of the fundamental elements of consumer protection. In this respect, European legislation treats labelling not merely as a commercial act, but as a legal obligation of the operator responsible for the product. Under Article 8 of Regulation (EU) No 1169/2011, responsibility for food information lies with the operator under whose name or business name the product is placed on the market. If that operator is not established in the European Union, the corresponding responsibility lies with the importer into the Union market.[19] This provision establishes a direct link between the entity that markets the product and the reliability of the information provided to the consumer. In the case of beverages declared "alcohol-free", the responsible operator must ensure that information on alcohol content complies with the applicable requirements. This includes observing the limits laid down for the product category, the accuracy of declarations and the avoidance of presentations that may create a false impression. Responsibility is not limited to the text printed on the packaging. In accordance with the relevant provisions, it also extends to information presented through advertising and other forms of commercial presentation. In this context, laboratory results, production documentation and quality-control procedures are important means of substantiating the manufacturer's declarations.

5.5. The Consumer's Right to Accurate Information

The legal protection of the consumer rests on the principle that the decision to purchase a product should be made on the basis of reliable information. Under Article 7(2) of Regulation (EU) No 1169/2011, food information shall be accurate, clear and easy for the consumer to understand.[20] This principle acquires particular importance when the name of a product may be interpreted in different ways. If a beverage is declared "alcohol-free" while containing a measurable amount of ethanol, assessing the accuracy of the labelling requires an examination of its compliance with the relevant legislation and of the manner in which the information is presented to the consumer. The presence of ethanol does not automatically constitute evidence of deception if the use of the designation is permitted by the applicable provisions. Nevertheless, meeting a quantitative threshold does not necessarily preclude an examination of the overall manner in which the product is presented. This issue is particularly important for consumers who avoid alcohol for religious, health or personal reasons. In such cases, information on ethanol concentration and the production process may influence the consumer's decision, even where legislation does not require every technological detail to be disclosed on the label. Transparency should therefore be treated not merely as the formal fulfilment of legal obligations, but also as an element of the trustworthiness of the relationship between manufacturer and consumer.

5.6. The Legal Framework in the Republic of North Macedonia

In the Republic of North Macedonia, food safety and product labelling requirements are governed by national legislation and the relevant implementing regulations.

One of the fundamental acts is the Law on Food Safety (*Закон за безбедност на храната*), while specific requirements for the labelling and presentation of products are also laid down in the relevant rulebooks. The Food and Veterinary Agency is the competent institution for a significant part of the

supervision and enforcement of food safety requirements. The documentation published by this institution also includes the Rulebook on the Manner of Food Labelling, published in Official Gazette No. 118/2005.[21] However, before it is used in an analysis of current legislation, its amendments, supplements and the provisions that remain in force must be verified. For the purposes of this study, the key question is whether national legislation sets a specific ethanol limit for beverages declared "alcohol-free", and whether this limit varies according to product category. The documentation examined at this stage has not confirmed the existence of a general provision establishing a single threshold for all beverages marketed under this designation. For this reason, it would be methodologically inaccurate to present a limit used in other jurisdictions automatically as a legal norm of North Macedonia. A definitive determination requires an examination of the consolidated versions of the legislation, of implementing acts for specific categories of beverages and, where necessary, of the official interpretation of the competent authority.

5.7. Regulatory Implications for Halal Standardisation

The differences between the legal definitions of "alcohol-free" beverages show that halal standardisation cannot rely solely on the commercial classification of a product. A reliable certification system must distinguish between compliance with labelling requirements and compliance with the religious criteria of the applicable standard. In this respect, information on ethanol content is a necessary, but not the only, element. Production documentation, the origin of ingredients, the use of processing aids and the traceability of the process may be equally important in reaching a certification decision. Such an approach does not seek to replace the competences of state authorities, but to complement the legal assessment with the specific requirements of halal standards. In this way, consumer protection and the integrity of certification become two mutually supportive objectives, without being regarded as legally or methodologically identical. For halal standardisation, these principles provide an important, but not sufficient, basis. Assessing religious permissibility requires an independent examination grounded in the technical documentation, the analytical results and the normative requirements of the relevant standard.

6. ANALYSIS OF EMPIRICAL STUDIES: ETHANOL CONTENT, LABELLING AND CONSUMER PERCEPTION

6.1. Purpose and Selection of Studies

A review of the empirical literature makes it possible to move from a theoretical treatment of beverages declared "alcohol-free" to an assessment of results obtained through psychological experiments, laboratory analyses and market studies. For this purpose, studies were selected that address three interrelated dimensions: the consumer's ability to distinguish beverages by alcohol content, the accuracy of the analytical determination of ethanol, and the way in which product characteristics are communicated through labelling. The studies do not share the same research object, nor are their methodologies comparable in every respect. Their results are therefore analysed separately, respecting the limits of the evidence that each source provides.

6.2. First Case: The Placebo Effect and the Perception of Alcohol Content

One of the early studies addressing the relationship between beverage composition and consumer perception is that of Kevin J. Corcoran and Daniel J. Segrist, published in 1993 in the journal

Addictive Behaviors.[22] The authors examined the possibility of using non-alcoholic beer as an alternative to placebo beverages in psychological experiments. Participants were presented with four samples: two beers classified as non-alcoholic, O'Doul's and Sharp's, a light beer, Busch Light, and a regular beer, Busch. The results showed that participants rated the alcohol content of O'Doul's significantly lower than that of the light and regular beers. The rating for Sharp's, however, was not significantly lower than for the other categories. On average, participants attributed to both non-alcoholic beers a content close to that of a light beer, approximately 3%. These results do not represent chemical measurements of ethanol in the samples studied. They reflect the participants' subjective estimates and show that the sensory characteristics of a beverage can influence the perception of its alcohol content. The relevance of this study to our topic lies in the distinction between the composition of a product and its interpretation by the consumer. A beverage with reduced ethanol content may be perceived as having a higher alcohol content, depending on its taste, aroma and the expectations of the individual. The study does not, however, demonstrate that participants experienced physiological intoxication, nor that the products analysed contained the concentrations they estimated. Its conclusion concerns the credibility of non-alcoholic beer as an experimental placebo. From the standpoint of halal standardisation, this case demonstrates that sensory perception cannot be used as a criterion for determining the chemical composition or the religious permissibility of a product.

6.3. Second Case: Laboratory Determination of Ethanol in Fermented Beverages

A study of direct relevance to the verification of commercial declarations is that of Gisele Gonçalves Bortoleto and Winston Pinheiro Claro Gomes, published in 2022 in the journal *Sítio Novo*.[23] The aim of the research was to determine the ethanol content of fermented beverages marketed with claims of low alcohol content or the absence of alcohol. The authors analysed eleven samples by gas chromatography with sampling of the vapour phase above the liquid (*headspace*) and flame ionisation detection, a method known by the abbreviation HS-GC-FID. This technique enables the separation and quantification of ethanol, providing an analytical basis for comparing the results with product declarations and the relevant requirements. Of the eleven samples examined, four were found to comply with the legal requirements used in the study, six showed ethanol content above the recommended levels, and one had a lower content than the value declared on the label. These results show that a discrepancy between measured content and the commercial declaration should not be treated merely as a theoretical possibility. It can be identified through the analytical control of products available on the market. Nevertheless, the legal interpretation of the findings must be confined to the legislation and product categories that the authors took as their reference. The results do not prove that all beverages declared "alcohol-free" contain ethanol above the permitted limits. For halal certification bodies, this study supports the need for documented laboratory analyses and for checks of consistency between technical specifications, measurement results and manufacturers' declarations.

6.4. Third Case: Comparison of Non-Alcoholic Beers by Production Technology

Another empirical study, published in 2022 in the journal *Beverages*, examines the influence of production technologies on the chemical composition and flavour characteristics of pilsner-style non-alcoholic beers.[24] The research covered twenty commercial products, which were analysed in order to assess the relationship between the production method and the final characteristics. Four beers labelled

"0.0" had ethanol contents ranging from 0.01% to 0.04% by volume. In the remaining sixteen products, the concentration ranged from 0.08% to 0.43%. These data are of particular importance for the interpretation of the declaration "0.0". They show that such a figure on a label does not necessarily imply the absence of any measurable amount of ethanol.

The study did not, however, classify these results as general breaches of labelling requirements. On the contrary, the authors examined them in relation to the German criteria applicable to the products analysed. Beers produced by restricted fermentation generally showed lower ethanol content, but the production method also influenced other chemical and sensory characteristics. This shows that the final ethanol concentration is not sufficient to describe the entire technological profile of a product. Within the framework of halal assessment, the findings support the need to distinguish quantitative information on alcohol content from documentation on the method of production.

6.5. Fourth Case: The Accuracy of Laboratory Methods for Dealcoholised Wines

An issue of particular importance for the reliability of analytical results is the choice of measurement method. In 2022, Laura Bey, Rachel West, Simone Madaras and Eric Wilkes of the Australian Wine Research Institute published a technical study on the accuracy of ethanol determination in no- and low-alcohol wines.[25] The authors analysed eighteen commercial wines selected from different categories, including red, rosé, white and sparkling wines. The samples were tested using two methods: near-infrared (NIR) spectroscopy and gas chromatography with flame ionisation detection (GC-FID). The results showed that the NIR method systematically gave higher values than GC-FID, particularly when the ethanol concentration was very low. The authors attributed this possible discrepancy to analytical interference from other alcohols present in the product. When the ethanol content exceeded 0.3% by volume, the results of the two methods converged. This finding is methodologically significant because it shows that laboratory analysis, too, must be interpreted with due regard to the selectivity, sensitivity and limitations of the technique used. A result reported as alcohol content cannot automatically be treated as a specific measurement of ethanol if the method is also sensitive to other compounds. For this reason, the verification of beverages declared "0.0%" requires the use of methods suitable for very low concentrations, as well as the documentation of measurement uncertainty.

6.6. Fifth Case: Labelling Transparency of Reduced-Alcohol Wines

In addition to chemical composition, contemporary literature has also examined the way in which information on alcohol is presented on product packaging.

A study by Melanie J. Pirinen, Tamara Bucher, Emma Beckett and Taiwo Olusesan Akanbi, published in 2026 in the journal *Beverages*, analysed the labels of no- and reduced-alcohol wines at selected retail outlets in Australia.[26] The authors identified variations in the use of descriptors, in the presentation of alcohol percentage and in nutrition information. In the category of no-alcohol wines, the expression "Zero alcohol" accounted for 41.3% of the descriptors identified, and "Alcohol free" for 23.9%. Alcohol content as a percentage by volume was displayed on the front label of fewer than half of the products in this category. These results show that information on alcohol content may be communicated in different ways, even within the same commercial category. The study, however, was a label audit and did not constitute a laboratory analysis of ethanol content. It therefore cannot be used as evidence that the products examined contained more alcohol than they declared. Its significance lies

in documenting variations in terminology and in the presentation of information, which may affect consumers' understanding of the labelling.

6.7. Comparative Interpretation of the Findings

The studies reviewed demonstrate that the problem of "alcohol-free" beverages involves dimensions that must be analysed separately, yet in relation to one another. The research of Corcoran and Segrist shows that the perception of alcohol content may be influenced by sensory characteristics and consumer expectations. The study by Bortoleto and Gomes provides laboratory evidence of discrepancies between measured ethanol content and the relevant requirements or declarations in a limited group of products. The analysis of pilsner-style beers demonstrates that even products labelled "0.0" may contain measurable concentrations of ethanol, without this necessarily implying a breach of legislation. The research of the Australian Wine Research Institute highlights the importance of selecting the analytical method, while the label audit documents variations in the way information is communicated. These findings support a common conclusion: the assessment of beverages declared "alcohol-free" cannot rest on a single, isolated indicator. Ethanol concentration, the measurement method, the technological process and the commercial information represent different elements of an overall control system. From the perspective of halal certification, this means that decision-making must rest on traceable documentation and clearly defined criteria, avoiding both the automatic acceptance of a product on the basis of its label and its rejection without a full technical and juridical-religious examination.

6.8. Recommendations Arising from the Analysis of the Scientific Studies

The comparative analysis of empirical studies highlights the need to improve the control mechanisms for beverages declared "alcohol-free", particularly with regard to labelling accuracy, the reliability of laboratory analyses and transparency towards the consumer. The results reviewed show that ethanol content cannot be assessed solely on the basis of the trade name, and that interpreting analytical data requires knowledge of the production technology and of the regulatory requirements. It is nevertheless necessary to distinguish the documented risk of alcohol consumption from the effect of very low concentrations of ethanol in particular products. The studies analysed in this paper do not provide sufficient evidence to establish a general level of health risk for each of these categories. For this reason, the recommendations are grounded in the principle of accurate information and of caution adapted to the circumstances. **First, the clarification and harmonisation of labelling terminology is recommended.** The designations "alcohol-free", "0.0%", "low-alcohol" and "dealcoholised" should be used in accordance with clear definitions, based on measurable criteria and on the relevant legal provisions. International harmonisation of these definitions would help to reduce ambiguity in cross-border trade and strengthen consumer protection. **Second, the analytical control of ethanol content needs to be improved.** Laboratory studies demonstrate the importance of using methods appropriate for the determination of low concentrations. It is therefore recommended that analyses be performed by competent laboratories using validated methods, with documentation of the limits of detection, the limits of quantification and the measurement uncertainty. Results should be interpreted in relation to the requirements applicable to the relevant product category. **Third, the strengthening of controls during production and storage is recommended.** Verification of alcohol content need not be confined to a single analysis at the end of the technological process. For products in which further

fermentation is possible, manufacturers should assess microbiological stability and the effect of storage conditions throughout the shelf life. The frequency of analyses should be determined on the basis of a risk assessment and the characteristics of the product.

Fourth, manufacturers' responsibility for the transparency of information should be increased. Commercial declarations should be supported by technical documentation and by reliable analytical results. The use of expressions that may create the impression of a complete absence of ethanol calls for particular care, especially when the product contains measurable amounts of this substance. Information should be presented clearly, intelligibly and in accordance with the relevant legislation. **Fifth, consumer education on the interpretation of labels is recommended.** Studies on the perception of alcohol content show that sensory characteristics and individual expectations may influence the subjective assessment of a product. Public information should therefore explain the distinction between the trade name, the measured ethanol concentration and the method of production. This is particularly important for consumers who avoid alcohol for health, religious or personal reasons.

Sixth, the consideration of specific informational measures for vulnerable groups is suggested. Competent authorities may assess the need for guidance or warnings tailored to particular categories of consumers. Such measures should be based on scientific risk assessments and on the requirements of proportionality, without creating the impression that every measurable concentration of ethanol necessarily produces the same health consequences.

Seventh, the establishment of documented criteria for the halal certification of reduced-alcohol beverages is recommended. The assessment should not be limited to the declaration "alcohol-free" or to a single laboratory result. It should encompass the origin of raw materials, the method of fermentation, dealcoholisation processes, processing aids, added ingredients and the traceability of production. The conclusion on religious permissibility should rest on the applicable standard and on the assessment of the competent certification body.

Eighth, closer cooperation is needed between scientific institutions, regulatory authorities and halal standardisation bodies. Such cooperation would enable the exchange of analytical data, the improvement of audit procedures and the development of joint guidelines for the assessment of products that present technological or legal ambiguity. In conclusion, the studies reviewed support the need for an integrated approach in which laboratory control, documentation of the production process, labelling accuracy and consumer protection are treated as complementary elements. For halal certification, this approach is of particular importance, because the credibility of a product is determined not merely by its commercial declaration, but by its documented compliance with technical and juridical-religious requirements. The implementation of these recommendations would contribute to greater market transparency, stronger institutional accountability and the protection of the integrity of halal certification.

7. INTERNATIONAL HALAL STANDARDS AND CRITERIA FOR THE ASSESSMENT OF BEVERAGES DECLARED "ALCOHOL-FREE"

7.1. Halal Standardisation as a Conformity Assessment System

Halal standardisation constitutes a system of technical, organisational and normative requirements

through which the conformity of products and production processes with certification criteria is determined. In the case of beverages declared “alcohol-free”, the importance of this system stems from the fact that the ethanol concentration in the final product does not necessarily describe its origin, the method of production or the ingredients used. International practice includes documents with different functions: standards that set out product requirements, standards for the competence of certification bodies, accreditation documents, guidelines for laboratories and specific national procedures. These documents do not necessarily have the same legal force or scope of application. Consequently, comparing them requires a distinction between the general requirements of standardisation and the specific criteria applied by authorities or certification bodies. For the purposes of this study, attention is focused on the documents of the Codex Alimentarius, the OIC/SMIIC standards and the certification systems used in Türkiye, Malaysia and Indonesia.

The analysis is limited to technical and institutional aspects, while the juridical-religious argumentation is addressed in the concluding part of the paper.

7.2. Codex Alimentarius Guidelines for the Use of the Term “Halal”

The Codex Alimentarius Commission, established within the framework of the FAO and the WHO, has adopted the document *General Guidelines for Use of the Term “Halal”*, identified by the code CXG 24-1997.[27] This document contains international guidance on the use of halal claims in the labelling of food products. Point 3.1.3 identifies alcoholic drinks and intoxicating or harmful drinks among the unacceptable categories, while point 3.1.4 extends the scope of scrutiny to additives derived from such ingredients. The importance of this document lies in its establishment of a general framework for the assessment of halal claims. However, CXG 24-1997 does not set a general numerical ethanol threshold for all beverages declared “alcohol-free”. Its use as a reference should therefore be confined to the requirements the document expressly sets out. It cannot serve as a source for attributing a specific percentage of ethanol without the support of another standard.

7.3. OIC/SMIIC 1:2019 – General Requirements for Halal Food

One of the fundamental documents of international standardisation is OIC/SMIIC 1:2019, *General Requirements for Halal Food*, developed within the framework of the Standards and Metrology Institute for Islamic Countries.[28] The standard sets out general requirements for halal food at the various stages of the food chain, including the sourcing of raw materials, production, processing, packaging, labelling, transport, storage and service. According to SMIIC’s official description, the document also includes requirements relating to beverages, ingredients, equipment, hygiene, verification and traceability. For products declared “alcohol-free”, the importance of the standard lies in its comprehensive approach to the production chain. Within this framework, the technical assessment should make it possible to identify the origin of the raw materials, the substances used during processing and the stages at which ethanol may be formed or added.

A product obtained through restricted fermentation and a product dealcoholised after conventional fermentation may exhibit similar ethanol concentrations, yet their technological documentation differs. For this reason, certification requires the product to be assessed against the specific provisions of the standard, and not merely on the basis of its trade name. However, the public description of OIC/SMIIC 1:2019 is not sufficient to establish specific numerical ethanol limits or to interpret particular exemptions.[29] These requirements must be verified in the full text of the standard, according

to the relevant edition and provision.

7.4. OIC/SMIIC 2:2019 – Requirements for Halal Certification Bodies

The OIC/SMIIC 2:2019 standard, *Conformity Assessment – Requirements for Bodies Providing Halal Certification*, addresses the competence, impartiality and consistency of the operations of certification bodies.[30] Unlike OIC/SMIIC 1:2019, which focuses on the requirements for halal food, this document establishes the institutional framework for carrying out certification. SMIIC explains that the standard is based on the principles of conformity assessment, including references to ISO/IEC 17065 and other certification-related documents. In the case of "alcohol-free" beverages, its importance lies in the necessity of a documented and impartial assessment process. The certification decision must rest on sufficient evidence of conformity with the requirements of the applicable standard. The manufacturer's documentation, the process audit and the test results may serve as complementary sources of information. Accordingly, a laboratory report determining the ethanol concentration must not be confused with a halal certificate. The report presents the result of a measurement, whereas the certificate is the outcome of a broader conformity assessment procedure.

7.5. OIC/SMIIC 35:2020 – Competence of Halal Testing Laboratories

The reliability of analytical results is an important element of certification, particularly when products with low ethanol concentrations are assessed. The OIC/SMIIC 35:2020 standard, *Conformity Assessment – General Requirements for the Competence of Laboratories Performing Halal Testing*, addresses the competence requirements for laboratories performing testing for halal purposes.[31] This document must be distinguished from standards that determine the permissibility of a product. Its function is to support the reliability of laboratory activity, not to replace certification criteria.

For ethanol analysis, the relevant considerations are the choice of method, its suitability for the food matrix, the accuracy of results and the documentation of measurement limitations. A result expressed as "0.0%" or "ethanol not detected" requires interpretation in relation to the sensitivity of the method. The absence of an analytical signal does not necessarily prove the absolute absence of the substance. Consequently, laboratory results should be used within their technical limits and in relation to the requirements established by the relevant standard.

7.6. Requirements for Additives and Processing Aids

In addition to the ethanol formed during fermentation, the assessment of beverages requires an examination of the ingredients added during formulation and processing. In this regard, OIC/SMIIC 24:2020, *General Requirements for Food Additives and Other Added Chemicals to Halal Food*, is a dedicated document on additives and chemical substances added to halal food.[32] Its relevance to beverages relates to the use of flavourings, colourings, preservatives and other substances that may differ in origin or composition. In some formulations, ethanol may be used as a solvent or carrier for aroma compounds. For this reason, the assessment of a beverage should not be confined to the ethanol formed during fermentation. Supplier documentation, ingredient specifications and information on the production process are necessary to identify the substances used and their origin. Acceptability criteria should be determined in accordance with the specific provisions of the applicable standard. The presence of a substance in the formulation and its concentration in the final product are two elements that may require separate assessment.

7.7. The Halal Certification System in Malaysia

Malaysia has developed an institutional system of halal certification in which the Department of Islamic Development Malaysia (JAKIM) plays a central role. One of the key documents is the *Manual Prosedur Pensijilan Halal Malaysia (Domestik) 2020*, which sets out the procedures for halal certification in the domestic market.[33] The Manual is applied together with Malaysian standards, halal management documents and other relevant requirements. In assessing beverages, the Malaysian system takes into account composition, the origin of raw materials, the production process and the conditions of certification. The comparative material reviewed for this paper mentions a limit of 0.1% ethanol. However, this value cannot be presented as a general threshold for all beverages without specifying the document, the product category and the concrete conditions of application.

Likewise, the requirements for ethanol used as a solvent in flavourings must be distinguished from the criteria for beverages produced through alcoholic fermentation. For this reason, the Malaysian approach is important as an example of a system that combines technical standards with institutional procedures, but it should not be reduced to a single ethanol percentage.

7.8. The Indonesian Halal Assurance System

Indonesia represents another advanced model of halal control and certification. In this country, the halal assurance system has historically been based on the HAS 23000 documents, while the institutional framework has been further developed through state structures for halal product assurance. The system documents address the control of raw materials, production processes, traceability and the responsibility of operators for maintaining compliance.[34] The material used for this study mentions a limit of 0.5% ethanol for certain product categories. However, this limit cannot be interpreted as a general authorisation to certify any beverage containing ethanol up to this level. The distinction between food categories, the origin of the ethanol and the nature of the technological process remains essential for interpreting the requirements. Furthermore, the historical HAS 23000 documents should not automatically be regarded as a complete description of Indonesia’s current regulatory framework. For this reason, any specific assessment must identify the document applicable at the time of certification and the authority competent to interpret it.

7.9. GİMDES Certification Criteria in Türkiye

GİMDES is a certification body that applies its own criteria in assessing halal conformity. According to the comparative material presented for this study, GİMDES takes a restrictive approach to beverages produced through alcoholic fermentation, taking into account not only the final ethanol content but also the technological history of the product. Under this approach, subsequent dealcoholisation is not automatically treated as a sufficient condition for admitting the product to certification.[35] This model illustrates the importance that some certification bodies attach to the origin of a product and to its production process. However, the criteria of a single certification body should not be presented as general provisions of Turkish legislation or as a position binding on all international standardisation institutions. The use of specific numerical limits and particular prohibitions requires verification of the official GİMDES document, its version and the relevant product category.

7.10. Comparison of Standardisation Approaches

The review of international documents reveals significant differences in their function and scope of application (Table 1).

Standard or system	Main scope of application	Relevance to “alcohol-free” beverages
Codex CXG 24- 1997	Guidelines for halal claims	Composition, processing and labelling
OIC/SMIIC 1:2019	Requirements for halal food	The product and the production chain
OIC/SMIIC 2:2019	Competence of certification bodies	Assessment and certification decision
OIC/SMIIC 35:2020	Competence of laboratories	Reliability of analytical results
OIC/SMIIC 24:2020	Additives and added substances	Origin and use of ingredients
JAKIM – Malaysia	National certification procedures	Composition, process and documentation
Indonesian system	Halal conformity assurance	Control of raw materials and process
GİMDES – Türkiye	Specific certification criteria	Origin and technological history of the product

The comparison shows that the documents examined do not all establish the same quantitative ethanol limit. Some address product requirements, while others define the competence of institutions or verification procedures. The assessment of a beverage should therefore begin with identifying the applicable standard and its specific requirements.

7.11. The Approach of the Agency for Halal Standard in the Republic of North Macedonia

In the institutional material presented for this study, the Agency for Halal Standard, operating within the Islamic Religious Community of the Republic of North Macedonia, describes an approach that attaches particular importance to the origin of the ethanol and to the production process.[36] According to the criteria presented, products manufactured through intentional alcoholic fermentation are not automatically accepted for certification, even when they subsequently undergo dealcoholisation. Likewise, the indication “0.0%” is not regarded as sufficient evidence of halal conformity. In this model, technological documentation is of particular importance, since it makes it possible to identify the stages of production and the source of the ethanol.

However, in order to present this approach as a formal, binding requirement, it is necessary to identify the institutional act that adopts it, its version and its scope of application. Until this documentation is confirmed, the criteria mentioned should be treated as an institutional approach presented in the study material, not as a verbatim citation of a published standard.

8. CONCLUSIONS AND FINAL RECOMMENDATIONS

8.1. General Conclusions of the Study

This study has examined the problem of beverages declared “alcohol-free” from the perspectives of food technology, laboratory analysis, labelling legislation, Islamic jurisprudence and halal standardisation. Its principal aim has been to identify the differences between the commercial meaning of the term “alcohol-free”, the actual ethanol content and the criteria that should be taken into account when assessing halal conformity. The review of the scientific literature, normative documents and juridical-religious sources yields several fundamental conclusions. **First**, the designation “alcohol-free” does not necessarily signify the absolute absence of ethanol. Its regulatory meaning may vary according to jurisdiction and product category. **Second,** the final ethanol content depends on the

production technology. Restricted fermentation and subsequent dealcoholisation are different processes, even when the final products exhibit similar ethanol concentrations. **Third,** empirical studies show that ethanol may be measurable in some products marketed as nonalcoholic. Its presence, however, does not in itself demonstrate a legal infringement or halal nonconformity unless the relevant assessment criteria are identified. **Fourth,** labelling legislation and halal certification standards serve different functions. A product may satisfy the legal requirements for marketing without necessarily meeting the criteria of a particular halal standard. **Fifth,** the Qur'an and the Sunnah establish the prohibition of intoxicating beverages. Applying this prohibition to contemporary products containing traces of ethanol, however, requires distinguishing between the nature of the beverage, the origin of the substance and the technological process. **Sixth,** Islamic jurisprudence has developed important concepts for dealing with the transformation and dilution of substances. However, *istiḥāla* and *istihlāk* cannot be applied automatically on the basis of a single ethanol percentage. **Seventh,** the resolutions of contemporary fiqh institutions demonstrate the importance of distinguishing between intoxicating beverages, alcohol used as a solvent and substances present in mixtures. These resolutions must be interpreted according to their specific subject matter and conditions. **Eighth,** international halal standards cannot be reduced to a single numerical ethanol limit. They encompass requirements concerning the product, ingredients, production process, the competence of certification bodies and the reliability of laboratory analyses.

Ninth, halal certification requires a documented assessment in which laboratory results are complemented by auditing, traceability and the verification of ingredients. **Finally,** consumer trust rests on the transparency of information and the integrity of the certification system. It follows from these conclusions that the assessment of beverages declared "alcohol-free" should rest on an integrated model that neither treats ethanol concentration as the sole criterion nor equates a commercial declaration with halal status.

8.2. Concluding Remarks

The problem of beverages declared "alcohol-free" demonstrates that technological development and the expansion of the food market create new challenges for legislation, standardisation and Islamic jurisprudence. The results of this study show that a commercial declaration cannot replace the scientific and normative assessment of a product.

"Alcohol-free" does not necessarily mean the absolute absence of ethanol; nor does "0.0%" in itself constitute evidence of halal conformity. This conclusion does not rest on denying the importance of labelling or of laboratory analysis, but on recognising their limits. Labelling informs the consumer of the declared characteristics of the product. Laboratory analysis determines the composition of the sample within the limits of the method used. The halal standard sets out the conformity requirements, while Islamic jurisprudence provides the juridical-religious basis for interpreting questions of permissibility. None of these elements can fully replace the others. In this context, the integrity of halal certification requires a stable relationship between scientific knowledge, institutional competence and juridical-religious responsibility. For this reason, the assessment of beverages declared "alcohol-free" should rest on transparency of composition, traceability of production, the reliability of analytical verification and the documented application of certification criteria. Only through such an approach can it be ensured that halal certification does not remain a formal commercial declaration, but represents a reliable system of conformity assurance, in the service

of the consumer, the manufacturer and the integrity of halal standardisation.

Notes

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(O-13) MUSLIM ATTITUDES AND AWARENESS TOWARDS ISTIḤĀLAH AND ḤALĀL IN NON-OIC COUNTRIES: A COMPARATIVE STUDY OF THE UNITED KINGDOM AND IRELAND

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Abstract

Istiḥālah (substantial transformation) is one of the most consequential yet under-researched concepts in contemporary Ḥalāl discourse, governing whether an originally impure or prohibited substance may acquire a new, permissible identity through complete chemical or physical change. This study examines awareness, knowledge and attitudes toward Istiḥālah and the broader concept of Ḥalāl among Muslims living in the United Kingdom (n = 55) and the Republic of Ireland (n = 27), drawing on an 82-respondent, GDPR-compliant online survey. Using Mann–Whitney U tests and chi-square analyses, the study finds that UK and Irish respondents report broadly similar general awareness of Istiḥālah($p = 0.106$), but differ significantly in how they resolve concrete transformation scenarios: Irish respondents were markedly more likely to report uncertainty about gelatin from non-dhabıha slaughtered Ḥalāl animals (48.1% “unsure” vs. 7.3% in the UK; $\chi 2$ $p = 0.0003$) and about consuming pork-derived gelatin claimed to be transformed (25.9% “unsure” vs. 3.6% in the UK; $\chi 2$ $p = 0.0047$). UK respondents reported significantly greater ease finding acceptable Ḥalāl food locally ($p = 0.028$), while Irish respondents reported significantly greater perceived difficulty living as a Muslim minority ($p = 0.012$). These findings suggest that Istiḥālah literacy is not simply a function of national context but is shaped by local Ḥalāl infrastructure, certification visibility and community density, with implications for certification bodies (HMC, IFI) and for harmonised UK–Ireland Ḥalāl standards.

Keywords: Istiḥālah, Ḥalāl awareness, minority Muslim communities Ḥalāl certification, UK–Ireland comparative study

(O-14) DIGITAL TRUST AND INTEROPERABILITY FOR THE GLOBAL HALAL ECOSYSTEM: A FEDERATED FRAMEWORK

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Abstract

Introduction: The global halal certification ecosystem is highly fragmented, with accreditation authorities, recognition authorities, and certification bodies operating under diverse national and regional standards, processes, and data models. Trust continues to rely on websites, portable document format certificates, and manual verification, making cross-border recognition, supplier validation, ingredient verification, and certificate authentication slow and vulnerable to fraud. Previous research has frequently proposed blockchain-based approaches; however, the challenge of establishing trust within the halal ecosystem is not solely technological, but fundamentally institutional and regulatory.

Objective: This paper proposes a Federated Digital Trust and Interoperability Framework and defines the Halal Trust Protocol as a domain-specific interoperability protocol for the secure, verifiable, and decentralized exchange of halal certification information. The objective is not to replace existing accreditation, recognition, or certification processes, but to provide a standardized interoperability and digital trust layer that connects them while preserving the autonomy of every participating organization.

Methodology: The proposed framework aligns with the principles of international accreditation and certification standards used within the halal ecosystem while building upon established digital trust technologies, including public key infrastructure, verifiable digital credentials, trusted lists, and transparency protocols. The protocol introduces standardized trust statements describing accreditation, recognition, certification scope, ingredient classification, slaughter method, credential status, and trust relationships.

Results and Discussion: The proposed framework illustrates how global digital trust and interoperability can be achieved without requiring centralized governance or blockchain consensus. By separating trust ownership, trust publication, and trust evaluation, accreditation authorities and certification bodies retain full ownership of their certification information while independent verifiers apply recognition policies appropriate to their own jurisdictions. The practical applicability of the framework is demonstrated through a proof-of-concept implementation illustrating representative cross-border verification scenarios and a phased digital trust maturity model supporting incremental adoption.

Conclusion: The proposed framework provides a practical roadmap toward a globally interoperable halal trust ecosystem while preserving existing governance structures. It establishes a foundation for future capabilities including ingredient verification, supplier validation, digital conformity assessment, and artificial intelligence-assisted certification.

Keywords: Halal certification, digital trust, interoperability, federated architecture, trust framework

(O-15) WEB PLATFORMS IN HALAL CERTIFICATION: CURRENT STATUS, CHALLENGES AND OPPORTUNITIES FOR INTEROPERABILITY

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Abstract

Introduction: The digital transformation of halal certification processes has become increasingly important for improving the efficiency, transparency, traceability, and reliability of halal assurance systems. Halal certification bodies employ a wide range of digital solutions, from publicly accessible databases of certified products and companies to integrated web-based platforms supporting application submission, document management, certification-process monitoring, audit management, corrective actions, and certificate issuance. Despite these developments, substantial differences remain in the degree of digitalization, functional scope, data structure, and technological maturity of existing systems. In particular, limited interoperability among independently developed platforms represents a significant challenge to efficient cross-border verification, data exchange, and mutual recognition within the global halal ecosystem.

Objective: The objective of this study was to assess the level of publicly verifiable digitalization of selected halal certification systems, identify their principal digital functionalities, and evaluate the current scope and limitations of interoperability and structured data exchange among such systems.

Methods: A pilot comparative analysis was conducted on publicly accessible web platforms of eight halal certification systems representing different geographical regions. For the purpose of systematic assessment and comparison, a preliminary Digitalization and Interoperability Index – DII-Public was developed. The index comprises 15 indicators grouped into three domains: digitalization of the certification process (0–10 points), public verification and transparency (0–10 points), and interoperability and data exchange (0–10 points), with a maximum overall score of 30 points. The analysis included only functionalities that could be verified through publicly accessible official digital sources. The assessed features included online application procedures, electronic document management, digital monitoring of certification processes, databases of certified companies and products, verification of certificate validity and status, QR-code or barcode-based verification, registers of recognized foreign halal certification bodies, and publicly documented mechanisms for digital data exchange.

Results and Discussion: The preliminary analysis demonstrated substantial variation in the level and scope of digitalization among the systems examined. The most advanced functionalities were generally associated with digital management of certification procedures and public verification of the halal status of certified products, companies, and certificates. In contrast, interoperability and automated exchange of structured data between independent halal certification systems were found to

be the least developed components. Several distinct models of digitalization were identified, ranging from integrated platforms supporting most stages of the certification workflow to systems primarily designed for public verification of certificates and certified products. The findings also indicate that a high level of internal digitalization does not necessarily correspond to an equally advanced level of external interoperability. The paper presents the detailed results of the DII-Public analysis and a comparative assessment of the level of digitalization, public verification, and interoperability across the analyzed systems.

Conclusion: The digitalization of halal certification is progressing, but the heterogeneity of existing technological solutions, data structures, and certification workflows continues to limit effective interoperability at the international level. Standardization of core certification data, harmonization of digital verification procedures, and the development of secure mechanisms for structured data exchange could provide a basis for improved connectivity among halal certification systems. Such an approach may contribute to enhanced transparency, traceability, certificate authenticity verification, and digital trust across the global halal ecosystem.

Keywords: halal certification; web platforms; digitalization; interoperability; digital verification; DII-Public.

(O-16) FROM FOOD WASTE TO WEALTH: A HALAL CIRCULAR NUTRITION FRAMEWORK FOR TRANSFORMING FOOD BYPRODUCT INTO SUSTAINABLE FUNCTIONAL FOODS

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Abstract

Billions of tons of agricultural and processing by-products are generated by global food supply chain annually, which results in profound economic losses and severe environmental degradation. Simultaneously, there is a surging global demand for sustainable, health promoting functional foods that are in accordance with the rigorous religious and ethical standards specially those that are included in the rapidly expanding Halal market. This research proposes a novel, multidisciplinary Halal Circular Nutrition (HCN) framework that is designed systematically to upcycle high value food byproducts into premium, nutrient dense functional food ingredients, which effectively converts industrial waste into economic wealth. The methodology integrates advanced ecofriendly green extracting technologies like ultrasound assisted extraction and subcritical water processing to efficiently isolate vital bioactive compounds, including polyphenols, dietary fiber and protein from raw byproducts matrices. Halal-by-Design verification matrix is one of the core innovation of this study. It comprehensively screens all processing aids, enzymes and raw material to ensure that strict compliance which includes Halal (permissibility) and Tayyib (wholesomeness and purity) principles are throughout the entire production lifecycle. After extraction, the engineered functional foods will undergo a rigorous assessment of their structural integrity, nutritional content, and sensory characteristics, along with evaluations for antioxidant activity and shelf-life stability. By integrating circular bioeconomy practices with stringent religious dietary standards, this research addresses a crucial gap in current sustainable food systems. The expected results will offer food manufacturers a scalable, compliant, and zero-waste operational model. In the end, this framework will reduce waste management expenses, create profitable new revenue opportunities, and provide scientifically supported, sustainable functional foods that meet the ethical and health needs of the global halal consumer.

Keywords: Circular Nutrition; Food Byproducts; Halal Food Tech; Sustainable Functional Foods; Waste-to-Wealth Upcycling

(O-17) THE HALAL FOOD WASTE PARADOX: QUANTIFYING NUTRITIONAL, ECONOMICS AND ENVIRONMENTAL VALUE LOSS ACROSS THE FOOD SUPPLY CHAIN

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Abstract

Food waste is increasingly recognized as a major challenge because it represents not only the loss of edible food, but also the loss of nutrients, money, water, energy, land, and other resources invested throughout the food supply chain. Within halal food systems, this issue creates a distinctive paradox. Halal principles emphasize moderation, responsible consumption, ethical handling, cleanliness, and avoidance of unnecessary waste, yet food continues to be discarded at different stages from production to final consumption. This study aims to examine the halal food waste paradox by quantifying the nutritional, economic, and environmental value lost across selected stages of the food supply chain. The study will use a mixed methodological approach to identify the quantity, type, source, and stage of food waste. Wasted foods will be categorized into major food groups and assessed using direct measurement and relevant records where available. Nutritional losses will be estimated by calculating the energy, protein, carbohydrate, fat, vitamins, and minerals contained in discarded foods using recognized food composition sources. Economic losses will be determined by estimating the monetary value of wasted food at the point where the loss occurs. Environmental losses will be assessed through indicators such as greenhouse gas emissions, water use, energy requirements, and other resources associated with food production, handling, and disposal. Information from consumers, food service operators, retailers, and other relevant stakeholders may also be collected to explore behavioural, cultural, operational, and religious factors that contribute to food waste. By examining food waste through nutritional, economic, and environmental perspectives together, the study is expected to provide a more complete understanding of its true value loss within halal food systems. The findings may identify the stages and food categories responsible for the greatest losses and highlight practical opportunities for prevention. The research may support culturally appropriate strategies that improve resource efficiency, strengthen food security, reduce environmental pressure, and encourage food practices that are more consistent with the ethical and sustainability principles associated with halal consumption. Ultimately, the study seeks to generate evidence that can guide policy makers, food businesses, institutions, and households toward measurable reductions in avoidable food waste over time.

Keywords: Halal food systems; Food waste; Nutritional loss; Economic loss; Environmental sustainability

(O-18) ZIA FRANCY HOME RESTAURANT: A MODEL OF LOCAL, INCLUSIVE, AND ZERO-WASTE HALAL HOSPITALITY IN THE HEART OF SALENTO.

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Abstract

The Zia Francy Home Restaurant project, the first halal-certified home restaurant in Salento, represents a concrete case study on how the halal economy can become an engine of sustainable growth, territorial enhancement and cultural inclusion.

Born in the heart of Puglia, the format integrates the principles of the halal economy with the gastronomic traditions of Salento, demonstrating that local authenticity and halal compliance can coexist in a virtuous way, generating social and economic value.

The activity is based on three pillars:

Food sustainability, through the use of local halal ingredients, short supply chains, seasonality and zero-waste cooking practices.

Cultural inclusion, welcoming Muslim and non-Muslim travelers in a domestic environment that promotes dialogue, mutual knowledge and respect for diversity.

Territorial innovation, reinterpreting Salento recipes — such as ciceri and tria, bread balls, potato pitta, wild vegetables, extra virgin olive oil and local fish — in a halal key, without distorting the gastronomic identity of the territory.

The halal certification of the format guarantees high standards of quality, safety and food ethics, while the "home-based" approach reduces the environmental impact, promotes female microentrepreneurship and strengthens the network of small local producers.

The result is a replicable model of Mediterranean halal hospitality, capable of generating economic growth, reducing waste and promoting a more conscious, responsible and culturally sensitive tourism.

Zia Francy's experience shows that the halal economy is not just a set of dietary rules, but an ecosystem of values that can transform domestic cooking into a laboratory of sustainability, hospitality and local development.

A concrete example of how Salento can dialogue with the world, remaining profoundly itself.

Keywords: inclusion, welcoming atmosphere, innovation, sustainability, food experience

(O-19) CAN INGREDIENTS DESIGNED BY GENERATIVE ARTIFICIAL INTELLIGENCE BE HALAL? PRECISION FERMENTATION AND ISLAMIC LAW

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Abstract

Gelatin, collagen and other animal-derived ingredients remain persistent challenges in halal food, cosmetics and pharmaceuticals. Generative artificial intelligence is now used to discover and design protein sequences, which engineered microorganisms produce through precision fermentation without any animal being used. The resulting ingredients can be molecularly identical to animal proteins, including porcine proteins, yet halal rules were developed around animals and physical sources, not digital genetic information. This paper asks under what conditions such ingredients can be considered halal. Using qualitative doctrinal analysis with a multiple case approach, it examines three categories: proteins from plant, microbial or computationally generated sequences; animal-free dairy and egg proteins; and animal-free collagen and gelatin. Each is assessed against origin (asl), transformation (istihalah), dissolution (istihlak), necessity (darurah), widespread need (umum al-balwa) and blocking the means (sadd al-dharai), drawing on contemporary jurisprudential scholarship, rulings on analogous cases such as vaccines and cultured meat, and the halal assurance literature. The findings show that halal status depends less on the final molecule than on four verifiable factors: the source of the genetic information, the host organism, growth media and processing aids, and the purity of the final product. Plant, microbial and permissible animal sequences fit within existing rules, whereas porcine sequences require collective scholarly deliberation. Authentication tools based on artificial intelligence may also misclassify such ingredients. The paper proposes a four-step decision framework for certification bodies and a halal-by-design documentation principle, supporting a sustainable, lower-waste halal economy.

Keywords: Generative artificial intelligence, Precision fermentation, Halal certification, Istihalah, Islamic jurisprudence

1. Introduction

Animal-derived gelatin and collagen have long been among the most contested ingredients in the halal economy. They are used across food, cosmetics and pharmaceuticals and are frequently sourced from porcine material or from animals not slaughtered according to Islamic law (Herdiana et al., 2024; Mohamad Hussaini et al., 2024; Leone et al., 2026). Halal assurance systems have responded with ingredient declarations, supplier certification and laboratory authentication, all of which presume that an ingredient can be traced back to a physical source.

That presumption is now being unsettled by two converging technologies. The first is precision fermentation, in which yeasts, bacteria or filamentous fungi are engineered to produce a specific target protein, including dairy proteins, egg proteins and collagen, without the use of animals (Teng et al., 2021; Augustin et al., 2024; de Moura Campos et al., 2025; Food and Agriculture Organization of the United Nations, 2025). The second is artificial intelligence applied to biological design. Deep learning systems can predict protein structures with high accuracy (Jumper et al., 2021), generate functional

protein sequences that do not exist in nature (Madani et al., 2023) and design new proteins for specified functions (Watson et al., 2023). In food science, artificial intelligence is already used to discover functional ingredients and to optimise ingredient substitution for sensory, nutritional and cultural requirements (Doherty et al., 2021; Oz & Oz, 2025). Combined, they allow the "origin" of an ingredient to be a digital sequence rather than an animal.

The halal literature on artificial intelligence has not yet addressed this shift. Existing studies concentrate on traceability, fraud detection, certification efficiency and consumer engagement (Azwar & Usman, 2025; Battour et al., 2025; Nawaz et al., 2025; Sunmola et al., 2025; Khan et al., 2026; Lahmar & Al Qaruty, 2026; Riaz et al., 2026). Applied systems classify existing products from label text, spectra or amino acid profiles (Winiarti et al., 2025; Yuswan et al., 2025; Sitorus & Arianti, 2026; Supriyati et al., 2026), and the first generative applications are chatbots that explain certification rules (Rozi & Rakhmawati, 2025). In all of these, artificial intelligence verifies products; it does not create them. Novel products such as in vitro meat remain an acknowledged research gap (Ellahi et al., 2025). Jurisprudential work on novel foods, meanwhile, has examined cultured meat and vaccines (Hamdan et al., 2018; Hamdan et al., 2021; Jamaludin et al., 2025), but not ingredients whose design is generated computationally. Certification bodies are therefore left without guidance on a practical question: when an ingredient is molecularly identical to an animal protein, possibly a porcine one, but no animal was used in its production, is it halal?

This paper addresses three research questions: (1) how generative artificial intelligence and precision fermentation change the way ingredients are created; (2) whether classical jurisprudential concepts can determine the halal status of such ingredients; and (3) what framework certification bodies should use to assess them. It contributes a case-based jurisprudential assessment, a four-step decision framework and a halal-by-design documentation principle.

2. Methods

2.1. Research Design

The study adopts a qualitative design that combines doctrinal jurisprudential analysis with a multiple case approach. Doctrinal analysis suits the research problem because it concerns the classification of new objects under existing legal and ethical categories rather than the measurement of behaviour.

2.2. Case Selection

Three ingredient categories were selected to represent increasing levels of jurisprudential difficulty. Case A covers proteins whose sequences come from plants or microorganisms, or are generated de novo by artificial intelligence without an animal counterpart. Case B covers animal-free dairy and egg proteins whose sequences originate from animals whose products are permissible. Case C covers animal-free collagen and gelatin whose sequences may replicate porcine proteins. Categories were used because proprietary production details are rarely disclosed.

2.3. Sources and Analytical Procedure

Three bodies of peer-reviewed material were examined: (a) technical literature on precision fermentation and on artificial intelligence in protein and ingredient design; (b) jurisprudential and halal science literature on origin (asl), transformation (istihalah), dissolution (istihlak), necessity (darurah), widespread need (umum al-balwa) and blocking the means (sadd al-dharai), including their application to gelatin, vaccines and cultured meat; and (c) literature on halal assurance and authentication. Each case was mapped to its production stages, and each stage was assessed against the

relevant principles. Positions of the classical schools were taken from contemporary scholarly sources rather than reconstructed by the author. The resulting assessments are analytical and indicative; they are not fatwas.

3. Results

3.1. Where Generative Artificial Intelligence Enters Ingredient Creation

The literature indicates four points at which artificial intelligence shapes an ingredient produced by precision fermentation. The first is discovery, in which models screen large collections of natural proteins for a target function such as emulsification, gelling or sweetness (Doherty et al., 2021). The second is design, in which generative models propose new or modified sequences (Madani et al., 2023; Watson et al., 2023), supported by structure prediction (Jumper et al., 2021). The third is production, in which the chosen sequence is synthesised, inserted into a host microorganism, expressed, separated from the host and purified (Augustin et al., 2024; de Moura Campos et al., 2025). The fourth is formulation, in which artificial intelligence optimises how the ingredient is combined with others (Oz & Oz, 2025). A decisive feature follows from this chain. When a sequence is chemically synthesised from digital data, no tissue, cell or genetic material from the reference animal needs to enter the process at any stage. The link between the ingredient and the animal is informational, not physical. Figure 1 maps these stages to the halal checkpoints developed in Section 3.3.

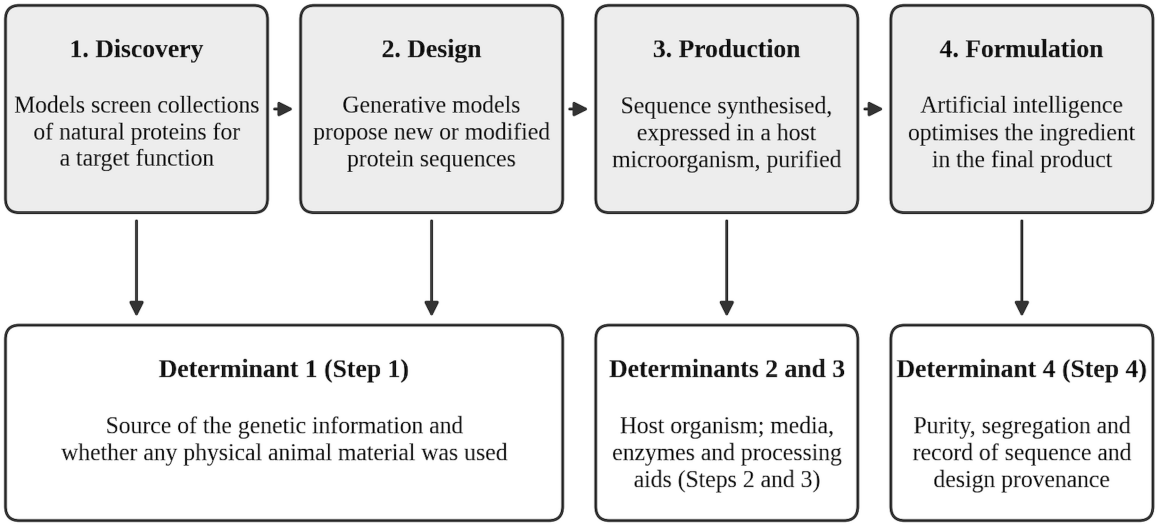

Figure 1.

Stages where generative artificial intelligence shapes an ingredient produced by precision fermentation, and the corresponding halal checkpoints

Note. Prepared by the author; determinants and steps refer to Section 3.3 and Table 2.

3.2. Jurisprudential Assessment of the Three Cases

Table 1 summarises the assessment of the three cases.

Table 1.

Indicative jurisprudential assessment of ingredients designed with artificial intelligence and produced

by precision fermentation

Case	Source of sequence information	Physical animal material in the process	Principal considerations	Indicative assessment
A. Plant, microbial or de novo proteins	Plants, microorganisms, or de novo design by artificial intelligence	None	General permissibility of things; status of host organism and inputs	Halal, subject to halal inputs and a non-harmful host
B. Animal-free dairy and egg proteins	Animals whose products are permissible without slaughter	None	Origin already permissible; status of host organism and inputs	Halal, subject to halal inputs
C. Animal-free collagen and gelatin with porcine sequences	Porcine proteins	None, where the sequence is synthesised from digital data	Whether prohibition attaches to substance or to information; transformation by analogy; blocking the means	Doubtful (mushtabah); referred to collective scholarly deliberation

Note. Assessments are analytical and indicative; they are not fatwas. Case definitions follow Section 2.2.

Case A. Proteins derived from plant or microbial sequences, or generated by artificial intelligence without a natural animal counterpart, fall under the general principle that things are permissible unless evidence establishes otherwise. The remaining questions concern the production environment rather than the protein: whether the host organism is harmful and whether growth media and processing aids are halal. The latter is not trivial, because culture media can contain animal-derived components, and plant-based media have been developed partly to secure halal and vegetarian status (Ayu et al., 2023).

Case B. Where sequences originate from animals whose products are permissible without slaughter, such as milk and egg proteins, the origin raises no prohibition. The analysis converges with jurisprudential work on cultured meat, which treats the permissibility of the source and the purity of the culture medium as decisive conditions (Hamdan et al., 2018; Hamdan et al., 2021). Precision fermentation is arguably easier to accommodate than cultured meat, because it requires no cells from the animal at all.

Case C. The difficult case is a protein that replicates a porcine sequence. Porcine collagen extracted from animal tissue is classified as prohibited in mainstream Sunni jurisprudence irrespective of industrial processing (Leone et al., 2026). Recombinant production differs in a way the classical rules did not anticipate: the prohibited animal contributes information, not substance. Two positions can be constructed. A restrictive position invokes blocking the means, holding that approving porcine-sequence proteins would normalise porcine identity in the halal market and weaken consumer trust. A permissive position argues that impurity (najasah) and prohibition attach to a physical substance (ayn), that no part of the pig is present, and that jurists who accept transformation as changing the legal status of a substance, notably within the Hanafi and Maliki schools, provide an analogical basis for permissibility (Jahangir et al., 2016; Kamali, 2021). Yet transformation in its classical sense presupposes a prohibited substance that later changes, and no such substance exists here, so the analogy is imperfect in both directions. This paper therefore classifies Case C as doubtful (mushtabah) and refers it to collective scholarly deliberation rather than to individual certifiers.

3.3. Four Determinants and a Decision Framework

Across the three cases, the halal status of the ingredient depended less on the final molecule than on four verifiable determinants: (1) the source of the genetic information and whether any physical animal material was used to obtain it; (2) the permissibility and safety of the host organism; (3) the

halal status of all growth media, inducers, enzymes and processing aids; and (4) the purity of the final ingredient and its segregation from non-halal production. Table 2 converts them into a decision framework.

Table 2.

Proposed four-step decision framework for certification bodies

Step	Question	If satisfied	If not satisfied
1	Is the sequence derived from plants, microorganisms, permissible animals or de novo design, and was it obtained without physical material from a prohibited animal?	Proceed to Step 2	Porcine sequence without physical material: refer to Shariah board as doubtful. Physical prohibited material used: not halal
2	Is the host organism safe and free from impurity?	Proceed to Step 3	Not halal
3	Are all growth media, inducers, enzymes and processing aids from verified halal sources?	Proceed to Step 4	Not halal until inputs are replaced or certified
4	Is the final ingredient purified and segregated, with a complete record of sequence provenance and artificial intelligence design inputs?	Halal (Cases A and B)	Certification withheld pending documentation

Note. Steps correspond to the determinants in Section 3.3 and Figure 1.

4. Discussion

4.1. From Substance to Information

The central finding is that artificial intelligence moves the question of origin from the physical to the informational domain. Classical halal categories were built to track substances: where they came from, whether they were contaminated and whether they had been transformed. Ingredients designed with artificial intelligence and produced by precision fermentation may relate to an animal only through a sequence stored in a database, and in the case of de novo design, not even that. This supports the argument that Islamic engagement with artificial intelligence requires its own normative reasoning rather than borrowed benchmarks (Elmahjub, 2023), and it suggests that genetic information may be a new object of jurisprudence requiring collective ijtihad.

4.2. The Authentication Paradox

The analysis also reveals a practical risk for halal assurance. Authentication of gelatin and collagen relies on detecting species-specific genetic material or peptide markers, for example through quantitative polymerase chain reaction and mass spectrometry-based proteomics (Leone et al., 2026), and increasingly on machine learning models that recognise the molecular signature of the source species, such as classifiers that identify non-halal gelatin from its amino acid composition with very high accuracy (Yuswan et al., 2025). A recombinant protein that replicates a porcine sequence contains no genetic material from the animal, yet it may reproduce the porcine peptide and amino acid signature. It could therefore trigger a fraud alert despite containing no pig material, while a fraudulent tissue-derived product could falsely claim recombinant origin. Laboratory testing alone cannot resolve such cases; documentary evidence of how the sequence was obtained becomes indispensable. This is the basis of the proposed halal-by-design principle: producers that use artificial intelligence in ingredient design should keep a verifiable record of sequence provenance, design inputs, host strain and production inputs, available to auditors. Provenance frameworks that combine artificial intelligence with blockchain records, already proposed for halal compliance (Sunmola et al., 2025), could host such records.

4.3. Implications for Certifiers and Standard-Setters

Existing reviews present artificial intelligence as a tool for traceability and compliance monitoring (Khan et al., 2026; Riaz et al., 2026). The present findings add a second role: artificial intelligence as a generator of new ingredients that certifiers must evaluate. Legal analysis of artificial intelligence in Indonesian halal certification shows that current law permits its use for administrative tasks but does not regulate algorithmic accountability, human oversight or explainability (Yuanitasari et al., 2026). The findings therefore call for guidance from standard-setting bodies on recombinant and computationally designed ingredients, auditor competence in basic biotechnology, and a referral pathway for doubtful cases to jurisprudence academies. The documented limits of language models on religious questions, including confident incorrect answers and weaker performance in Arabic (Atif et al., 2025), and the residual error of even source-grounded halal chatbots (Rozi & Rakhmawati, 2025) caution against delegating such classifications to automated systems.

4.4. Sustainability and Consumer Trust

In line with the congress theme, precision fermentation may reduce dependence on animal by-products and on contested porcine supply chains, although its environmental performance depends on process choices such as energy and feedstock that life cycle assessments identify as hotspots (David et al., 2026). Acceptance depends on clear communication about process and safety (Hadi & Brightwell, 2021; Broad et al., 2022). For Muslim consumers, this includes transparent halal assurance.

5. Conclusion

This paper examined whether ingredients designed with generative artificial intelligence and produced through precision fermentation can be halal. Their status is determined by four verifiable factors rather than by the molecule itself. Ingredients from plant, microbial or de novo sequences, and from sequences of permissible animal products, can be accommodated within existing principles, provided that hosts and inputs are halal. Proteins replicating porcine sequences expose a gap in classical categories, because the prohibited animal contributes information rather than substance; these are best treated as doubtful and referred to collective scholarly deliberation. The four-step framework and the halal-by-design principle make these determinants auditable.

The study has limitations. It is analytical rather than empirical, classical positions were drawn from contemporary scholarship, and the technologies are evolving faster than published rulings. Future research should validate the framework with Shariah scholars, halal auditors and biotechnologists, examine acceptance among Muslim consumers, and study how certification bodies currently treat recombinant ingredients. Above all, the findings call on international jurisprudence academies to address genetic information as a distinct object of Islamic legal reasoning before these ingredients become widespread.

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(O-20) FROM WASTE TO HALAL WEALTH: VALUE-ADDED CEREAL COOKIES FOR A SUSTAINABLE HALAL ECONOMY

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Abstract

A test entitled ‘’utilization of fruits and vegetable waste in cereal based foods’’ was conducted in Department of Horticulture amid 2016-2018. Powder from the mango bit, pineapple pomace, banana peel and orange peel was composed. The wheat flour in the cookies detailing was substituted by MKP (mango kernel powder), PPP (pineapple pomace powder), CPP (carrot pomace powder), BPP (banana peel powder) and OPP (orange peel powder) at the rate of 0, 10, 20 and 30 percent. Cookies were prepared and were examined for physical (breadth, thickness and spread proportion), useful (water holding capacity, oil holding capacity and swelling capacity), chemical (moisture, ash, protein, fat, fibre, carbohydrate) and sensorial characteristics (appearance, colour, Enhance, taste, surface, overall acceptability). On the premise of generally sensory qualities, cookies prepared with consolidation of 10 per cent of MKP, PPP, CPP, BPP and OPP recorded higher worthiness scores as compared to other test.

Keywords: Cereals, Waste, Cookies, Sustainable, Halal economy

(O-21) FROM HALAL LOGO TO DIGITAL PROOF: TRANSPARENCY, TRACEABILITY AND CERTIFICATION CREDIBILITY IN HALAL CONSUMER TRUST

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Abstract

The digital transformation of halal assurance is moving the industry beyond reliance on static halal labels toward increasingly verifiable forms of product and certification information. This structured integrative review examines how digital technologies can strengthen traceability, transparency, certification credibility and consumer trust in halal food markets. The review synthesizes recent research on blockchain, quick response-based verification, Internet of Things monitoring, artificial intelligence, digital certification systems and laboratory-data integration from a consumer-trust perspective. The findings indicate that digital technology alone does not guarantee consumer trust. Rather, digital traceability provides assurance evidence, transparency makes that evidence accessible and understandable, and certification-body credibility provides institutional legitimacy. The review further identifies four interconnected dimensions of digital halal assurance: raw-material traceability, process and handling transparency, certification and testing transparency, and distribution transparency. Consumer knowledge, digital literacy, perceived usefulness and perceived risk may further influence whether digitally verifiable information is accepted as trustworthy. The proposed framework therefore conceptualizes digital halal assurance as a socio-technical trust pathway connecting digital assurance infrastructure, verification data, transparency, certification-body credibility, consumer trust and behavioral intention. The review contributes an integrated consumer-centered perspective to the growing literature on digital halal assurance and highlights the importance of combining technological capability with credible institutional governance. Future empirical research should examine how consumers across different markets respond to varying levels of digital verification and certification information.

Keywords: halal assurance, digital traceability, consumer trust, certification credibility, transparency

(O-22) FROM MENU PLANNING TO WASTE MONITORING IN FOODSERVICE SYSTEMS: THE HALAL AND SUSTAINABILITY PARADIGM

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Abstract

Introduction and Aim: In a globalized world facing rapid urbanization, growing populations, and the climate crisis, foodservice systems occupy a critical position regarding halal and sustainability targets in food systems due to their large production volumes and resource consumption. In these systems, menu planning undertakes responsibilities that extend beyond merely providing nutritional quality, consumer satisfaction, and cost control; it also encompasses reducing ecological footprints, preserving biodiversity, utilizing resources efficiently, and preventing waste. This study aims to present an integrated halal and sustainability paradigm encompassing menu planning, environmental indicators, and waste management strategies from production to consumption. Methods: Studies published between 2010 and 2026 were identified through systematic searches in the PubMed, Scopus, Web of Science, and Google Scholar databases. During the search process, the keywords "cafeteria/dining hall", "catering", "menu planning", "sustainability", "carbon footprint", "water footprint", "food waste", "ecological footprint", "food loss", "foodservice systems", "satisfaction", "institutional nutrition", "cost", "plate waste", "choice architecture", "bioavailability", and "nutritional value" were utilized. Results: Current evidence indicates that in foodservice systems, omnivorous menus containing animal-derived proteins—particularly red meat and dairy products—exhibit higher carbon emissions and water consumption compared to vegetarian/vegan menus; partially or completely replacing red meat with legumes, fruits, vegetables, and white meats with lower ecological footprints reduces the environmental burden by 20% to 55%. However, for vulnerable populations in growth and development stages and worker groups with high energy and quality protein requirements, such adjustments are scrutinized regarding nutritional adequacy, absorption efficiency, decreased consumer satisfaction stemming from plant-based meals, and resultant food waste. Concurrently, ecological footprints tend to increase as the demand for local and fresh produce declines; adopting a seasonal and local sourcing-oriented approach to menu planning is therefore essential. In terms of consumer behavior, positioning low-carbon options at the top of displays significantly increases their selection rate. Furthermore, waste management cannot be evaluated using a single metric; it must be monitored via multi-performance indicators alongside machine-based demand forecasting methods, accounting for kitchen preparation losses, holding times, procurement processes, plate waste linked to portion control, and overproduction-driven pan/tray residues. Implementing multilayered solid waste management systems (biogas, composting, and upcycling) within the kitchen production workflow can reduce the volume of solid waste by up to 90%. Conclusion: Halal integrity and sustainability in foodservice systems must be managed holistically from menu engineering to waste monitoring. Appropriate menu planning should be conducted in collaboration with registered dietitians—prioritizing seasonal and locally sourced ingredients while balancing lower ecological burdens, minimized plate waste, consumer satisfaction, and budget constraints tailored to consumer demographics. Within this scope, establishing artificial intelligence-driven traceability for food waste will ensure the prevention of waste—a core halal tenet—while reshaping choice architecture through innovative menu diversification and targeted educational initiatives.

Keywords: foodservice systems, menu planning, sustainability, food waste management, ecological footprint.

(O-23) "FARM-TO-FORK" HALAL FOOD ASSURANCE IN FOODSERVICE SYSTEMS

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Abstract

Introduction and Aim: While conventional perceptions associate halal compliance primarily with end-product testing or slaughtering practices in abattoirs, in foodservice systems it represents an active, holistic process encompassing logistics, storage, kitchen preparation, portioning, service stages, and supply chains from farm to fork. Multi-supplier networks, high-volume raw material inputs, the scarcity of halal-certified alternatives, non-standardized practices, and gaps in oversight mechanisms disrupt halal food assurance within foodservice systems. The aim of this study is to delineate the framework of "farm-to-fork" halal food assurance in foodservice systems, examining its integration dynamics with food safety systems and the factors that ensure its continuity throughout kitchen workflows. Methods: Studies published between 2010 and 2026 were identified through systematic searches in the PubMed, Scopus, Web of Science, and Google Scholar databases. The keywords "foodservice systems", "halal food assurance systems", "halal food chain", "catering", "halalan tayyiban", "food safety", "critical control points", "hygiene and sanitation", and "halal supply chain" were utilized during the search process. Results: The Halal Assurance System is essential for ensuring compliance with Islamic tenets throughout procurement, fostering consumer trust, and enhancing organizational operational efficiency. The integration of halal, quality, and safety processes guarantees that food is not only halal but also safe and of superior quality. In this regard, safeguarding the halal integrity of the chain, preventing contamination from farm to fork, maintaining transparency, and upholding standards require seamless collaboration across all operational tiers of food services. In foodservice systems, the prevention of cross-contamination and the identification of risk factors across all production processes are critical. It is imperative to ensure the feasibility and traceability of halal control points designed to manage critical control points, additives of questionable halal status, unverified emulsifiers, gelatin, flavoring agents, fats and their derivatives lacking label and certification verification, cross-contamination from kitchen equipment and cold storage units, porcine derivatives, non-halal slaughtered meat sources, and impure (najis) contaminants. This can only be realized through the knowledge, adherence, and awareness of foodservice personnel. However, empirical findings reveal operational deficiencies, including inadequate physical segregation procedures, lacking internal audit schedules, compromised record-keeping discipline, and managerial shortcomings, as well as a deficit of certified halal or definitively halal ingredients. Artificial intelligence-assisted analyses and digital traceability systems substantially augment verification, transparency, and oversight. Conclusion: Halal food assurance in foodservice systems constitutes a holistic guarantee extending beyond basic certification; it encompasses rigorous oversight across every farm-to-fork stage to ensure quality, food safety, hygiene, sanitation, and halal integrity. Sustaining

and assuring this system requires multidisciplinary collaboration among dietitians, food engineers, and institutional managers, robust regulations capable of preventing non-halal items from reaching the consumer's plate, the incentivization of food suppliers and catering enterprises toward halal certification and implementation, and the provision of targeted staff training. Individual choice-oriented frameworks must be broadened to encompass institutional procurement and food service specifications within foodservice systems, where a single operational decision directly impacts large consumer populations.

Keywords: Foodservice systems, halal food assurance, halal critical control points, food safety, traceability.

(O-24) HALAL LIFESTYLE AND CHRONONUTRITION

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Abstract

Introduction and Objective: The concept of Halal refers to practices permissible under Islamic law. Extending beyond mere dietary guidelines, it encompasses social, economic, and broader human domains. Structuring daily routines according to Halal principles is vital for Muslims. Nutrition, a fundamental component of the Halal lifestyle, is heavily influenced by daily metabolic processes. A dietary regimen aligned with the biological clock and shaped by diurnal metabolic variations is defined as chrononutrition. This study aims to examine the Halal lifestyle through the framework of chrononutrition and evaluate its potential health effects. Methods: This study reviews research published between 2010 and 2026 across the PubMed, Google Scholar, Scopus, and Web of Science databases. The search strategy targeted contemporary studies investigating the physiological and metabolic interactions between Halal dietary practices—specifically Ramadan fasting and Islamic intermittent fasting—and chrononutrition, with a focus on meal timing and circadian rhythms. Keywords utilized include ‘chrononutrition’, ‘halal lifestyle’, ‘ramadan fasting’, ‘circadian rhythm’, and ‘meal timing’. Irrelevant articles were excluded from the review. Results: The Halal lifestyle spans multiple sectors, including food, beverages, economics, tourism, logistics, and cosmetics. Islamic teachings provide specific guidelines regarding the timing of meals, sleep, and worship, alongside dietary composition and portion control. Principles such as eating in accordance with one's biological clock and sleeping in alignment with the light-dark cycle constitute the core of chrononutrition. While circadian-aligned nutrition consistently yields health benefits, fasting studies (such as Ramadan and time-restricted eating) require further long-term follow-up. Core elements—such as the fasting-feeding cycle, prayer-aligned sleep schedules, and Hadith-based energy regulation (e.g., the discouragement of overeating)—demonstrate significant overlap. This illustrates that Islamic teachings closely parallel modern chrononutrition, suggesting that evaluating the Halal lifestyle from a nutritional perspective yields scientifically valid outcomes. Conclusion: In conclusion, the striking resemblance between practices recommended by Islam and the contemporary science of chrononutrition is noteworthy. This perspective suggests that adhering to a Halal lifestyle may confer significant health benefits, though further research is required to fully explore this intersection.

Keywords: halal lifestyle, chrononutrition, ramadan fasting, circadian rhythm.

(O-25) MICROENCAPSULATED KELP EXTRACT: A WASTE-REDUCING, SDG-ALIGNED NUTRACEUTICAL FOR THYROID HEALTH

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Abstract

The brown macroalga kelp (Laminaria spp.) is a renewable, mineral-dense feedstock for nutraceutical uses because it accumulates iodine and trace minerals from saltwater at concentrations far higher than terrestrial plant sources. In order to increase the extract's bioavailability, regulate its release profile, and improve its physicochemical integrity and shelf life, this study assessed microencapsulation of kelp extract. Advanced techniques like Ultrasound extraction and Microwave extraction were chosen to recover bioactive chemicals because of their lower solvent-to-biomass ratios and shorter processing periods, which lowered energy input and extraction waste. Total iodine concentration and total phenolic content was used to assess extraction efficiency. After the extract was microencapsulated, the resulting microcapsules was examined for in vitro release kinetics, functional group retention (FTIR), encapsulation efficiency, particle size distribution, and morphology (SEM). Serum T3, T4, and TSH concentrations were measured using ELISA or radioimmunoassay and thyroid histology was analyzed using histopathological analysis in an induced-hypothyroid animal model to evaluate biological efficacy. To identify significance across treatment groups, the data was examined using a suitable statistical model. SDG 3, SDG 12 and SDG 14 all were impacted by the extraction and encapsulation approach. SDG 3 (Good Health and Well-Being) is addressed through the development of a marine-derived treatment for thyroid dysfunction; SDG 14 (Life Below Water) is addressed through the use of a renewable marine biomass source. Findings from this study were able to contribute preliminary data on the feasibility of kelp-derived microencapsulated formulations as a sustainable nutraceutical candidate for thyroid health support.

Keywords: Kelp Extract, Microencapsulation, Hypothyroidism, SDGs, Waste Reduction

(O-26) DIETARY ACCULTURATION, HALAL FOOD, AND HEALTH CONCERNS

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Abstract

Introduction-Objective: Individuals' diets are influenced by their resident culture and environmental factors. With the social changes experienced by immigrant groups, mandatory or voluntary differences can be observed in their food choices and dietary-patterns. In regions where Muslim individuals constitute a minority, halal food access and food security can become a significant issue. Accordingly, the objective of this review is to evaluate the health concerns that dietary acculturation may pose, particularly among immigrant and minority groups. Method: The study was conducted utilizing research published between 2010-2026 in PubMed, Google Scholar, Scopus, Web of Science databases, using the keywords 'dietary acculturation', 'halal-food-access', 'micronutrient-deficiency', 'Muslim immigrants', 'health-concern', 'anemia'. Articles irrelevant to the subject were excluded from the scope of the review. Results: Dietary acculturation can be defined as the process by which individuals or societies begin to adapt to the culture they are in contact with by abandoning their own culture. The contact and interaction of the immigrant population with the host country can lead to changes in dietary-habits; however, the degree of influence from the host country's habits varies. Studies demonstrate that individuals' diets are affected either negatively or positively depending on the status of the destination country. A shift in choices toward ultra-processed and energy-dense-foods causes a change in the disease burden, resulting in an increase in conditions such as obesity, diabetes, cardiovascular diseases among immigrant groups. Limited access to certain food groups for immigrants with low socioeconomic-status can also exacerbate nutritional problems, leading to an increased risk of disease. Simultaneously, the difficulty of accessing halal-food in regions where Muslims are a minority affects food preferences, potentially leading to deficiencies in individuals' nutrition. Conclusion: Consequently, changes in the food preferences of immigrants/minority groups and a decrease in food access can increase health risks. Among Muslim immigrants/minorities, the addition of the halal-food access criterion can further restrict the range of available foods. Making choices with low nutritional value alters individuals' dietary patterns, ultimately affecting the risk of contracting or developing diseases. There is a need for an increase in studies directly investigating the micronutrient deficiencies of Muslim immigrants in this context.

Keywords: halal food, migration, dietary acculturation, health concern.

(O-27) HALAL, HEALTHY AND CLEAN? NUTRITIONAL QUALITY, ULTRA-PROCESSING AND CONTROVERSIAL ADDITIVES IN HALAL-CERTIFIED PACKAGED FOODS

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Abstract

Background:

Halal certification primarily establishes compliance with religious dietary requirements; however, halal foods may also be associated with broader notions of purity, wholesomeness, quality, and safety. Whether these broader positive associations are reflected in the nutritional and processing characteristics of halal-certified packaged foods remains less clear. We examined three complementary product dimensions—nutritional quality, degree of processing, and the presence of selected controversial additives—in a large sample of halal-certified packaged foods.

Methods:

This cross-sectional study included 2,699 packaged foods identified as halal-certified. Nutritional quality was assessed using Nutri-Score, processing level using the NOVA classification, and additive profile using a predefined set of controversial additives. Favorable characteristics were defined as Nutri-Score A/B, NOVA 1–3, and absence of a controversial additive. Products with complete Nutri-Score and NOVA data (n=2,554) were classified according to the number of favorable dimensions. Product-category analyses and equal-category-weighted sensitivity estimates were used to assess the influence of category composition.

Results:

Among products with valid classifications, 61.4% were Nutri-Score D/E and 61.0% were NOVA 4. At least one predefined controversial additive was identified in 19.3% of products. Overall, 424 products (16.6%; 95% CI 15.2–18.1%) met all three favorable characteristics, whereas 485 (19.0%; 95% CI 17.5–20.6%) met none. A more restrictive unfavorable profile—Nutri-Score D/E, NOVA 4, and presence of at least one controversial additive—was observed in 15.9% (95% CI 14.5–17.4%). Findings were not explained by overrepresentation of a few food categories: the five largest categories comprised only 15.5% of the sample, and equal-category-weighted estimates were similar to observed values (19.0% vs 16.6% for the all-favorable profile; 14.5% vs 15.9% for the unfavorable three-domain profile). Marked heterogeneity was observed across food categories.

Conclusion:

Halal-certified packaged foods showed substantial heterogeneity in nutritional quality, processing level, and additive profile. Only a minority simultaneously combined a favorable nutrient profile, non-ultra-processed status, and absence of selected controversial additives. These findings suggest that nutritional quality, processing, and additive composition provide complementary information when characterizing the broader health-related attributes of halal-certified packaged foods.

Keywords: Halal certification; packaged foods; Nutri-Score; NOVA classification; ultra-processed foods; food additives; clean label

(O-28) A QUALITATIVE ASSESSMENT OF HALAL CRITICAL CONTROL POINTS (HCCPS) IN COSMETIC MANUFACTURING PROCESSES

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Abstract

Background: Maintaining halal integrity in cosmetic manufacturing is challenging because of complex supply chains, limited transparency regarding ingredient origins and derivatives, and potential cross-contamination during material handling and processing. Identifying and managing Halal Critical Control Points (HCCPs) is therefore important for maintaining halal assurance throughout manufacturing operations.

Objective: This study aimed to explore halal cosmetic manufacturing processes and examine how HCCPs, corrective actions, and verification procedures are identified and managed by Malaysian cosmetic manufacturers.

Methods: A qualitative multiple-case study was conducted involving purposively selected personnel from four Malaysian cosmetic companies representing different organisational backgrounds and halal management practices. Participants had relevant experience in cosmetic manufacturing and halal management, with eligibility criteria including more than five years of work experience. Interview data were transcribed in the original language and translated into English where necessary. Data were analysed using deductive and inductive coding followed by thematic analysis. Member checking, cross-case comparison, and a data saturation matrix were used to support data verification and examine recurring themes. HCCP identification was guided by the JAKIM product-processing flowchart, while corrective actions and verification procedures were examined using the Halal Risk Management Plan in the Malaysian Halal Management System (MHMS) 2020.

Results and Discussion: Three major operational HCCPs emerged from the findings: (i) raw-material procurement and sourcing, where inadequate verification of supplier documentation, ingredient origins, and complex derivatives may leave halal status unresolved; (ii) raw-material receiving and warehouse management, where inadequate delivery verification or segregation may allow materials of uncertain status to enter production or increase cross-contamination risks; and (iii) processing and utilities, where equipment residues, water filtration components, and cleaning-brush materials may introduce potential halal contamination. The findings distinguish these HCCPs from general halal controls, such as staff training, routine documentation, housekeeping, and implementation of standard operating procedures, which support overall halal assurance. HCCPs concern specific operational stages where inadequate control may compromise halal integrity and therefore require risk-appropriate monitoring, verification, and corrective action. This distinction is based on the potential consequences of control failure and the risks identified in the participating companies, rather than on a formal quantitative risk-scoring system. Corrective and verification practices included quarantine of doubtful materials, investigation of causes, documentation, corrective and preventive action, and internal auditing. Rejection or disposal may be necessary for confirmed non-compliant materials, while sertu is

relevant where contamination involving najis mughallazah requires the procedure under applicable halal requirements. Larger manufacturers used digital systems to support traceability and documentation, whereas smaller companies relied more on physical segregation, supplier verification, staff competency, and manual records. The findings were interpreted in relation to MS 2634:2019, MHMS 2020, and the Malaysian Halal Certification Procedure (Domestic) 2020.

Conclusion: The findings highlight the importance of risk-based halal assurance across procurement, receiving, storage, and processing. For small and medium enterprises (SMEs), practical measures include spreadsheet-based raw-material traceability, structured staff competency training, documented corrective-action procedures, and risk-based monitoring of identified HCCPs. Effective HCCP management may help prevent avoidable material and product losses and support resource efficiency; however, these sustainability benefits were not directly measured in this study. Further research should evaluate the cost-effectiveness of these measures and their effects on waste reduction, resource utilisation, and halal compliance across different manufacturing settings.

Keywords: Halal Critical Control Points (HCCPs), Halal Assurance System (HAS), cosmetic manufacturing, halal compliance, quality.

(O-29) TECHNICAL OBFUSCATION OF CARMINE IN RED COSMETICS: IMPLICATIONS FOR HALAL INTEGRITY, CONSUMER PROTECTION LAW, AND SDG 12 IN BANGLADESH

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Abstract

This study investigates the technical ingredient nomenclature disconnect and information transparency regarding carmine (CI 75470), a red pigment derived from dried female cochineal scale insects (Dactylopius coccus), in the context of Bangladesh's rapidly expanding domestic halal cosmetics market and statutory consumer protection law.

Using empirical data from a qualitative-dominant mixed-method research design comprising a purposive retail market audit of fourteen commercial red cosmetic products (n=14) and an exploratory pilot survey of halal-conscious consumer awareness (n=33), we examine ingredient disclosure practices, lay buyer comprehensibility, and statutory compliance under Sections 44 and 45 of Bangladesh's Consumer Rights Protection Act 2009 alongside classical Sunni Fiqh jurisprudence.

The findings reveal that while all sampled cosmetics formally list technical chemical terms such as CI 75470 or generic shade terms like Approved Colors, zero percent provide explicit plain language origin disclosures declaring insect derivation. Consequently, 84.8% of surveyed consumers fail to identify CI 75470 as carmine dye, and 72.7% remain completely unaware of its biological cochineal origin, exposing a profound technical disclosure gap between formal regulatory compliance and practical consumer understanding.

The results suggest that obscure numerical color codes effectively obfuscate material biological facts, depriving Muslim & Vegan consumers of the necessary ingredient transparency to make informed purchasing decisions aligned with their personal religious convictions across divergent Sunni schools of jurisprudence regarding insect consumption and ritual purity.

This study contributes to the literature by establishing a novel theoretical synthesis that bridges Islamic ethical mandates of Amanah (trustworthiness) and prohibition of Gish (deception) with domestic consumer protection statutes and corporate supply chain accountability targets under UN Sustainable Development Goal Targets 12.6 and 12.8.

The implications of these findings for regulatory enforcement bodies, national Shariah governance boards, cosmetic packagers, and ethical consumers are discussed through the proposed Integrated Transparency Framework, which mandates explicit, bilingual plain-language parenthetical origin declarations—such as CI 75470 (Insect-derived)—on cosmetic packaging.

Keywords: Halal Cosmetics, Carmine (CI 75470), Labeling Transparency, Consumer Rights Protection Act 2009, SDG Target 12

(O-30) MARKET ENTRY STRATEGIES FOR HALAL COSMETICS IN TÜRKİYE: AN ANALYSIS OF REGULATIONS, HALAL CERTIFICATION, AND WARDAH'S COMPETITIVENESS

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Abstract

This study examines potential strategies for Wardah, an Indonesian halal cosmetics brand, to enter the cosmetics market in Türkiye. It addresses the fact that a brand's halal identity alone does not establish its readiness to enter a foreign market. Market entry also requires compliance with applicable cosmetic regulations, credible halal certification, an understanding of market conditions and competitors, and a viable distribution strategy. This study adopts a qualitative desk-research approach combining a structured literature review, comparative regulatory analysis, and a Wardah case study based on secondary data. The analysis is organized around four dimensions: cosmetic regulatory readiness, halal-certification credibility, market evidence and competitive positioning, and distribution access and market-entry implementation. The preliminary analysis suggests that Wardah's halal positioning may be a potential international brand asset, but it is not sufficient to demonstrate regulatory readiness or commercial viability in Türkiye. The study therefore proposes a staged market-entry framework consisting of readiness verification, market validation, commercial preparation, and market testing and evaluation. Because the final review of market statistics, legal requirements, certification status, and company information remains to be completed, the recommendations should be treated as preliminary and verified before business implementation.

Keywords: Wardah; halal cosmetics; Türkiye; market-entry strategy; cosmetic regulation; halal certification; international trade.

1. INTRODUCTION

The halal cosmetics industry lies at the intersection of consumer needs, trust in ingredients and production processes, product-safety regulation, and brand strategy. For brands seeking to expand internationally, halal positioning may create differentiation, but market entry also depends on compliance with destination-country requirements, the credibility of certification, product suitability, and access to distribution channels.

Türkiye is a relevant context in which to examine these issues. The country has a domestic cosmetics industry and retail channels, while also being connected to international trade flows. Nevertheless, a market's demographic or religious characteristics alone do not demonstrate that a particular product will be commercially successful. Market opportunities need to be assessed using reliable data on market size, imports, consumer preferences, competitors, prices, and distribution.

Wardah was selected as the case because it is known in Indonesia for its halal cosmetics positioning and provides a context for examining how a brand's halal identity can be translated into a market-entry

strategy for Türkiye. However, the case selection does not imply that Wardah's products are already compliant with all Turkish requirements, that its halal certification will automatically be recognized, or that demand for its products has been established in Türkiye.

The central problem of this study is that readiness to enter Türkiye's cosmetics market cannot be assessed solely on the basis of Wardah's status as a halal brand. Readiness must also be assessed in terms of cosmetic regulatory compliance, the status and scope of halal certification, market and competitor evidence, and the company's commercial and operational capacity.

Based on this problem, the study addresses three research questions:

1. Which cosmetic regulatory and halal-certification issues should be assessed before Wardah enters the Turkish market?
2. What market and competitive factors need to be verified to evaluate Wardah's potential positioning in Türkiye?
3. How can these considerations be integrated into a practical market-entry framework?

The study aims to develop a market-entry framework for Wardah by integrating regulatory analysis, halal credibility, and commercial readiness. Its intended contribution is an integrated preliminary framework that connects technical market-entry requirements with business decisions. The framework is not presented as proof of commercial feasibility; rather, it identifies the evidence and verification steps needed before a market launch.

2. LITERATURE REVIEW AND ANALYTICAL FRAMEWORK

2.1 Halal cosmetics and consumer trust

Halal cosmetics concern ingredients, production processes, handling, and claims that must comply with the relevant halal standards. For consumers, a halal label or certificate may serve as a signal of trust, but its meaning depends on the credibility of the issuing body, the scope of certification, and the transparency of the information provided. Halal awareness should therefore be considered alongside other purchasing factors, including product performance, price, brand reputation, innovation, availability, and social influence.

The preliminary literature used as a starting point for this study includes research on Generation Z's adoption of halal cosmetics in Istanbul and research on halal-product awareness and purchase intention in Türkiye. These studies may help identify factors associated with consumer decisions, but their findings must be interpreted in light of their actual samples, methods, publication details, and research contexts. Findings from a particular age group or city should not automatically be generalized to all consumers in Türkiye.

2.2 Cosmetic regulation and halal certification

Cosmetic regulation and halal certification serve different purposes. Cosmetic regulation establishes legal obligations relating to product safety, composition, documentation, labelling, notification, and post-market oversight. Halal certification assesses conformity with relevant halal standards within the scope of a particular certification scheme. Compliance with cosmetic law does not automatically establish halal status, and halal certification does not replace mandatory cosmetic regulatory

compliance. Certification, accreditation, and recognition are also distinct concepts and should not be used interchangeably.

In the context of Türkiye, the analysis needs to examine national cosmetic regulations and their relationship with Regulation (EC) No 1223/2009 on cosmetic products in the European Union. Regulatory alignment or harmonization should not be assumed to mean that all procedures and obligations in the two jurisdictions are identical. The applicable Turkish legal texts, official guidance, and relevant administrative requirements need to be compared directly.

The Halal Accreditation Agency (HAK) should be discussed in accordance with its official mandate and scope. The existence of HAK is not sufficient to conclude that all halal certificates issued outside Türkiye are automatically accepted or, conversely, automatically rejected. The issuing body for Wardah's certificate, its accreditation scope, the standards applied, and the relevant recognition arrangements must be checked against current official sources.

2.3 International market-entry strategy

International market-entry strategy includes market selection, fulfilment of entry requirements, selection of local partners, product and communication adaptation, distribution-channel selection, and assessment of risks and costs. For cosmetics, regulatory compliance is a prerequisite, while commercial decisions should be supported by analysis of demand, competition, pricing, and distribution channels.

This study combines these considerations into one framework: (1) regulatory and halal readiness; (2) product and brand competitiveness; and (3) market access and commercial implementation. The framework connects the evidence gathered to actionable recommendations.

2.4 Research gap

Literature on halal cosmetics, consumer purchase intentions, and halal certification provides a foundation for understanding the industry. This study focuses on a more specific issue: how cosmetic regulation, the credibility of cross-border halal certification, and commercial strategy choices can be integrated into an assessment of market-entry readiness for an Indonesian halal cosmetics brand considering Türkiye. This research gap must be confirmed through a documented literature search. Accordingly, the study does not claim that the topic has never been researched; instead, it seeks to develop an integrated analytical framework relevant to the Wardah case.

3. RESEARCH METHODOLOGY

This study uses a qualitative secondary-data approach combining a structured literature review, comparative regulatory analysis, and a Wardah case study. This approach was selected because the study aims to map market-entry requirements and develop an initial strategy based on available evidence, rather than measure consumer behaviour through a primary survey or test actual sales performance.

The planned data sources fall into four groups. First, scholarly journal articles on halal cosmetics, consumer behaviour, halal certification, cosmetic regulation, and international market-entry strategy. Second, official legal and institutional sources from Turkish and European Union authorities, including documents on cosmetic regulation, notification systems, safety monitoring, and halal

accreditation. Third, official statistics and industry reports concerning the cosmetics market, imports, supplier countries, and distribution channels. Fourth, official Wardah company and product information relevant to brand positioning, product portfolios, and certification status.

The final search process must record the databases and websites actually used, search dates, publication period, keywords, and the number of documents identified and selected. Initial keywords may include “halal cosmetics Türkiye,” “halal cosmetics consumer behaviour Turkey,” “Turkish cosmetics regulation,” “EU Cosmetics Regulation 1223/2009,” “Türkiye halal accreditation,” “Wardah halal cosmetics,” and “cosmetics imports Türkiye.” Documents will be selected if they are relevant to the research questions, come from identifiable sources, and provide verifiable information. Sources without adequate bibliographic information or that make unsupported claims will be used sparingly or excluded.

The analysis is conducted through thematic coding in four categories: (1) cosmetic regulatory compliance; (2) halal certification, accreditation, and recognition; (3) market evidence and competitive positioning; and (4) market-entry strategy options. Comparative analysis is used to distinguish Turkish cosmetic requirements from the European Union framework and to separate legal obligations from strategic or commercial actions. The findings are then synthesized into a market-entry readiness framework.

This study has limitations. Because it relies on secondary data, it cannot directly measure Turkish consumers’ purchase intentions toward Wardah. It also cannot confirm commercial feasibility or certification acceptance without relevant product documentation, official confirmation, and company data. The recommendations are therefore positioned as an initial strategic assessment that must be verified before business implementation.

4. FINDINGS AND DISCUSSION

4.1 Dimension One: Cosmetic Regulatory Readiness

The preliminary review identifies several regulatory tasks that need to be examined before Wardah enters the Turkish market. These include appointing a local responsible person where required, preparing a Product Information File (PIF) or the applicable product documentation, completing notification procedures through the relevant system, complying with composition and safety requirements, meeting labelling requirements, and conducting post-market safety monitoring.

This list should be treated as a verification agenda, not as a definitive statement that every procedure takes exactly the same form or applies in the same way to every product. Current requirements need to be confirmed using official sources from the Turkish Medicines and Medical Devices Agency (TİTCK) and the applicable national regulations. Strategically, Wardah should conduct a regulatory gap assessment for each product considered for entry into Türkiye. The assessment should cover formulas and ingredients, safety documentation, product claims, labels, the responsible person, notification procedures, and post-market monitoring obligations.

The regulatory analysis must also distinguish Türkiye from the European Union. Regulation (EC) No 1223/2009 can serve as an important point of comparison, but compliance with EU regulations should not automatically be assumed to satisfy every procedural requirement in Türkiye. A provision-by-provision comparison and review of national implementation guidance are necessary before making

definitive legal recommendations.

4.2 Dimension Two: Credibility of Halal Certification

The preliminary review identifies halal certification as a key issue for Wardah. However, this study distinguishes three questions: whether Wardah's products have valid halal certificates; which body issued those certificates and what their scope covers; and how that body's status is treated under the relevant accreditation or recognition framework in Türkiye.

HAK should be analysed according to its official mandate as a halal accreditation body. Accreditation of a certification body is not the same as certification of a product. Recognition of a certificate across borders also cannot be inferred merely from the existence of an accreditation body. Before launching products, Wardah is therefore advised to seek written confirmation from the relevant authority or a competent certification partner concerning the certificate's status, the products covered, and any additional steps that may be required.

At the product level, supply-chain checks may cover ingredient origins, animal-derived ingredients, solvents, fragrances, and production processes and facilities, in accordance with the applicable certification standard. Particular ingredients should not be described as categorically prohibited without examining their type, origin, function, and the relevant standard's requirements. This approach treats halal as a claim that must be supported by credible documentation and governance.

4.3 Dimension Three: Market Evidence and Competitive Positioning

The preliminary review indicates a possible opportunity for global halal brands that combine halal claims, product quality, and a modern brand image. However, this opportunity cannot be considered established without market and consumer data. To strengthen the final analysis, the study should include recent statistics on the value and growth trends of Türkiye's cosmetics market, imports of cosmetic products under relevant HS classifications, leading supplier countries, and Indonesia's position where trade data are available.

Consumer analysis should draw on research whose methods and samples can be verified. For example, findings concerning Generation Z consumers in Istanbul may help explain factors affecting halal cosmetics adoption, but they do not automatically represent all consumer segments in Türkiye. The study should compare the influence of halal awareness and certification trust with product attributes, price, innovation, brand reputation, and social influence.

Competitive analysis should also be conducted at the product and segment levels. Wardah should be compared with brands that are genuinely relevant to the target product category, price range, positioning, claims, and sales channels. A brand should not be described as halal-certified based solely on perception or an unverified claim. Price and distribution data should preferably come from identifiable official websites, retailers, or sales channels, with the data-collection date recorded.

Until these data are available, the study cannot conclude that Wardah has a definite price, quality, or competitive advantage in Türkiye. Instead, Wardah's halal positioning can be treated as a potential asset that needs to be assessed alongside quality, product suitability, pricing, and distribution access.

4.4 Dimension Four: Distribution Access and Market-Entry Strategy

Distribution access determines whether regulatory readiness can be translated into sales. The

preliminary review highlights the importance of local partners and import preparation. Strategically, Wardah could evaluate several options, including working with a local distributor or importer, partnering with retailers, selling through e-commerce platforms, or adopting a phased approach through a limited market test. The final choice should be based on costs, brand control, distribution coverage, the partner's ability to meet regulatory requirements, and demand data.

Trade documents such as invoices, packing lists, certificates or documents of origin, and HS classifications need to be checked according to the product category and applicable import scheme. This list should not be treated as exhaustive for every import scenario; the importer and customs specialists should confirm the requirements in force at the time of the transaction. The selection of a local partner should also consider its ability to manage product documentation, labelling, complaint handling, post-market monitoring, and access to target distribution channels.

4.5 Synthesis: A Market-Entry Readiness Framework for Wardah

Based on the preliminary review, the market-entry strategy can be organized into four stages. Stage one is readiness verification: select priority product categories, gather formula and safety documentation, map regulatory obligations, and verify halal-certification status. Stage two is market validation: assess market size and trends, map competitors, examine price ranges and distribution channels, and identify the most relevant consumer segments. Stage three is commercial preparation: select local partners, adapt labels and communications, calculate landed costs, and determine the distribution model. Stage four is market testing and evaluation: where feasible, begin with a limited portfolio, monitor sales and feedback, evaluate consumer complaints, and revise the strategy based on measurable results.

This framework indicates that the market-entry decision should not be based solely on the appeal of halal identity or the size of the Muslim population. It should pass through checkpoints for regulatory readiness, certification credibility, commercial feasibility, and operational capacity. If a key prerequisite has not been met, the company should address the gap before undertaking a broader launch.

5. STRATEGIC RECOMMENDATIONS

Based on the preliminary analytical framework, five strategic recommendations are proposed for Wardah.

First, conduct a product-by-product regulatory audit before selecting the portfolio for Türkiye. The audit should examine applicable national requirements, safety documentation, notification, labelling, local responsibility, and post-market obligations. The output should be a gap matrix distinguishing mandatory requirements, documents already available, missing documents, responsible parties, and estimated completion times.

Second, verify halal-certification status and the applicable recognition pathway through official sources. Wardah should identify the issuing body, validity period, certificate scope, standards applied, and relevant accreditation status. Written confirmation should be obtained before the company makes claims about certificate recognition in Türkiye. This approach reduces the risk of inaccurate claims and helps build trust among consumers and business partners.

Third, select the initial portfolio based on market fit and documentation readiness, not merely on popularity in Indonesia. Priority products should be assessed in terms of target-consumer needs, differences in climate and usage habits, formulation, price range, packaging, and competition. Product or communication adaptations should be made only when supported by consumer analysis and relevant requirements.

Fourth, develop positioning that combines halal credibility with quality, safety, product benefits, and transparency. Marketing communications should avoid assuming that all consumers in Türkiye choose cosmetics primarily for religious reasons. Claims about ingredients, testing, or certification must be substantiated and comply with applicable advertising and labelling requirements.

Fifth, implement a phased market-entry strategy through competent local partners and measurable commercial testing. Before wider expansion, Wardah should assess distributor capabilities, access to sales channels, import costs, final consumer prices, customer support, and complaint-management mechanisms. Initial-stage evaluation may use indicators such as the number of active distribution channels, product availability, sales by channel, repeat-purchase rates where data are available, consumer complaints, and customer-acquisition costs.

These recommendations constitute an initial framework. Final priorities should be determined after market data, legal requirements, certification status, and relevant internal Wardah information have been obtained and verified.

6. CONCLUSION

This study examines Wardah's potential readiness to enter Türkiye's cosmetics market by integrating analysis of cosmetic regulation, halal certification, market conditions, and distribution strategy. The preliminary analysis indicates that Wardah's identity as an Indonesian halal cosmetics brand may form part of its international positioning, but it is not sufficient to demonstrate market-entry readiness or commercial success.

The eight steps identified in the preliminary review—appointing a local responsible person, preparing product documentation, completing notification through the applicable system, checking formula compliance, verifying halal certification, adapting labels, conducting post-market safety monitoring, and preparing for import and customs procedures—should be understood as a verification agenda that must be checked against current requirements. The analysis must distinguish cosmetic compliance from halal certification, and product certification from certification-body accreditation and cross-border recognition.

This study proposes a four-stage framework: verification of regulatory and halal readiness, market validation, commercial preparation, and market testing and evaluation. The framework can help connect technical requirements with business decisions and reduce the risk of a premature launch. Nevertheless, conclusions about Wardah's commercial potential in Türkiye remain preliminary because they require current market and trade data, measurable competitor analysis, legal and certification verification, and company information that can be confirmed.

Future research should strengthen this framework through systematic market-data collection and, where possible, interviews with regulators or regulatory experts, certification bodies, importers, distributors, retailers, and consumers. This would allow the proposed strategy to be assessed further in

terms of implementation and business feasibility.

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9. Official statistical sources to be added: Turkish Statistical Institute (TÜİK), relevant Turkish foreign-trade authorities, UN Comtrade, or other official sources providing cosmetics market and trade data. Specify the data series, HS category, period, and access date after the search is completed.

10. Official Wardah company sources to be added to verify brand positioning, product portfolio, halal claims, and published certification information.

(O-31) APPLYING A HALAL BUILT-IN WORK SYSTEM FRAMEWORK TO REDUCE WASTE AND SUPPORT GROWTH IN PHARMACEUTICALS AND COSMETICS

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Abstract

Avoidable waste in pharmaceutical and cosmetic manufacturing may result when the halal suitability of ingredients, suppliers, and processes is assessed only after substantial resources have been committed. The halal built-in principle, under which halal compliance is designed into products and processes from the outset, is reflected in OIC/SMIIC 50-1:2022 Halal Pharmaceuticals – Part 1: General Requirements, developed by SMIIC Technical Committee 16, for which Malaysia holds the secretariat. This paper links a halal built-in work system, developed through qualitative research in the Malaysian pharmaceutical sector, with these requirements to support waste prevention and wider adoption across OIC member states.

The underlying study combined document analysis with interviews involving fiqh scholars, halal authorities, health regulators, and industry representatives. The framework is grounded in Steven Alter's Work System Method, a systems-analysis approach originally developed for understanding information systems in organisations, which views a work system as one in which human participants and machines perform processes using information and technology to produce products and services for customers. The study adopted Alter's nine elements (customers, products and services, processes and activities, participants, information, technologies, environment, infrastructure, and strategies) and added fiqh principles as a tenth element, rearranging them into a halal built-in work system framework. Using Alter's one-page work system snapshot format, this paper maps these elements against the OIC/SMIIC 50-1 requirements, allowing manufacturers and regulators to see at a glance where the framework aligns with the standard, where it adds value, and what must be in place for an efficient halal built-in work system.

The framework's process, participant, information, and infrastructure elements correspond to the standard's requirements, while its fiqh, strategy, technology, and customer elements add explicit attention to areas that existing standards address only briefly. It also moves compliance upstream: early assessment of ingredient origins can reduce late reformulation, supplier qualification informed by technical and fiqh references can prevent unsuitable purchases, and coordinated responsibilities and traceability can limit rework and product rejection. Where no fatwa has yet been issued, as for some biotechnology inputs such as cell lines and materials of doubtful origin that undergo purification, the study recommends that manufacturers appoint Shariah advisors or committees, as practised in Islamic financial institutions, to interpret these areas and support fatwa requests.

Malaysia's experience, including a national halal pharmaceutical standard since 2012 and defined roles for religious authorities, health regulators, and industry, offers lessons for other OIC member states. The framework uses generic work-system elements rather than national institutions, hence other countries can map its roles to their own certification bodies, regulators, and fatwa councils. Application to cosmetics requires adaptation to the sector's ingredients and supply chains, and the proposed environmental and economic benefits remain to be tested through case studies in Malaysia and other OIC countries.

Keywords: halal built-in, OIC/SMIIC 50-1, work system snapshot, Shariah advisory, pharmaceuticals, cosmetics, waste prevention

(O-32) CAROTENOID PROFILING OF THREE MICROALGAE SPECIES ACROSS GROWTH PHASES FOR HALAL BIOACTIVE PRODUCTION

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Abstract

Halal pharmaceutical, nutraceutical and cosmeceutical products need bioactive ingredients that do not come from animals. Many carotenoid products on the market still use animal-derived capsules or alcohol-based extraction, and little is known about how carotenoids in candidate microalgae change as cultures grow, which makes it hard to decide which species to grow and when to harvest. Microalgae are halal-compliant by nature and make carotenoids used in sun-protective skincare, antioxidant supplements and provitamin A products. We followed the metabolomes of Nannochloropsis oculata, Nannochloropsis oceanica and Chlorella vulgaris at Days 0, 7, 10 and 14, with three biological replicates per time point, in Conway medium at pH 6.8 under continuous light and without nutrient limitation. Metabolites were extracted with methanol, chloroform and water. The chloroform layer was dried, saponified and analysed by liquid chromatography coupled with quadrupole time-of-flight tandem mass spectrometry, with one injection per replicate. Carotenoids were identified putatively from the mass-to-charge ratio of their expected ions and checked against elution order, detection frequency and published pigment profiles. Partial least squares discriminant analysis separated the three species clearly (goodness of fit 0.994, predictive ability 0.981), while growth phase explained far less. In Nannochloropsis oculata, β-carotene was below the detection limit in all three Day 0 replicates, appeared in all three Day 7 replicates and peaked at Day 10 ($p = 0.005$). A zeaxanthin-related signal in the same species was highest at Day 7 and absent from every Day 14 replicate ($p = 0.003$). In Chlorella vulgaris, a signal from lutein and/or zeaxanthin, two isomers we could not tell apart, was found in every replicate from Day 7 onwards with larger peak areas than at Day 0 ($p = 0.013$). Violaxanthin-related signals barely changed. Nannochloropsis oculata is best harvested between Days 7 and 10 for β-carotene and zeaxanthin, and Chlorella vulgaris at any point from Day 7 for lutein and zeaxanthin under standard conditions. We did not test stress treatments, so these figures reflect baseline output rather than maximum yield. Microalgae grown in mineral media are a naturally compliant source of carotenoids for the halal market.

Keywords: halal bioactive ingredients, microalgae carotenoid, β-carotene, harvest optimisation, untargeted metabolomics

1. Introduction

The halal economy now reaches well past food into pharmaceuticals, nutraceuticals, cosmeceuticals and personal care (Herdiana et al., 2024). Halal nutraceuticals were worth about USD 42 billion in 2024 and are forecast to reach USD 78 billion by 2032 (Inkwood Research, 2025). Halal cosmetics stood at USD 53 billion in 2025 and are projected to reach USD 143 billion by 2034, with Asia Pacific the largest market (Fortune Business Insights, 2025). Manufacturers in all of these sectors run into the same practical problem, which is finding raw materials that are clearly halal and toyyiban: free of porcine components, alcohol-based processing solvents and animal ingredients of unknown origin (Herdiana et al., 2024). Certification rules for medicines and cosmetics are getting stricter in Malaysia and Indonesia, so the demand for compliant active ingredients keeps growing.

Carotenoids are C40 isoprenoid pigments with a long list of commercial uses (Ambati et al., 2019). β-Carotene is sold as a provitamin A supplement in food and pharmaceutical products (Duan et al., 2024). Lutein and zeaxanthin protect the macula and are among the most valuable carotenoids on the market (Fu et al., 2023). Violaxanthin has shown anti inflammatory activity (Garg et al., 2024), and cosmetic formulators use carotenoids as UV protectants and anti-ageing antioxidants (Dutta et al., 2023; Mekinić et al., 2023). The trouble lies in how these products are made. Many are packed in bovine or porcine gelatin capsules, contain animal-derived emulsifiers or are extracted with ethanol, and each of these raises a halal question (Herdiana et al., 2024). Synthetic carotenoids avoid the issue, yet buyers increasingly ask for ingredients of natural origin (Duan et al., 2024).

Microalgae can fill this gap. They grow in defined mineral media without animal inputs, no slaughter is involved, and their pigments can be recovered by halal-compliant methods (Wan Sulaiman et al., 2023). *Chlorella vulgaris*, one of the most widely farmed green microalgae, makes mostly lutein, with smaller amounts of β-carotene, violaxanthin, neoxanthin and zeaxanthin (Pantami et al., 2020; Caetano et al., 2024). *Nannochloropsis* species are already grown commercially for omega-3 fatty acids. Their main carotenoid is violaxanthin, which occurs alongside vaucheriaxanthin, zeaxanthin, antheraxanthin, β-carotene and minor ketocarotenoids such as canthaxanthin, and they rely on the violaxanthin cycle for photoprotection (Lubián et al., 2000; Sun et al., 2022). Which carotenoids are made, and in what amounts, depends on the species, the growth phase and the culture conditions (Ambati et al., 2019; Duan et al., 2024).

For a producer, one simple question carries a lot of weight: when should the culture be harvested? Carotenoid content shifts as a culture ages (Esteves et al., 2024). During exponential growth the pigments mostly serve light harvesting, but as cells approach stationary phase, carbon can be diverted to storage and photoprotective compounds (Ambati et al., 2019). Shifts of this kind have been seen in several microalgae even without deliberate stress (Lubián et al., 2000; Rajput et al., 2022; Caetano et al., 2024). Measuring them under ordinary production conditions tells us what a normal commercial run would actually deliver.

Liquid chromatography coupled with quadrupole time-of-flight tandem mass spectrometry (LC-QTOF-MS/MS) can profile the metabolome, carotenoids included, without choosing targets in advance (Rivera et al., 2014; Todorović et al., 2022). Programs such as MS-DIAL then match the spectra against reference libraries like MassBank of North America (MoNA) (Tsugawa et al., 2015). In positive electrospray, a carotenoid may appear as a radical cation, a protonated molecule or an ion

that has lost water (Rivera et al., 2014; Maoka, 2023). When authentic standards are not at hand, the *m/z* of these expected ions, read alongside retention behaviour and the known pigments of the species, can still support a putative identification.

Here we profiled *N. oculata*, *N. oceanica* and *C. vulgaris* at Days 0, 7, 10 and 14 of standard cultivation in Conway medium at pH 6.8 under continuous light (Figure 1).

Carotenoids were identified putatively from the *m/z* of their expected ions, their elution order, how often they were detected and the published pigment profile of each species. The multivariate analysis followed the MetaboAnalyst workflow (Pang et al., 2024), and we tracked each carotenoid signal from one growth phase to the next. The aim was a practical one: to work out which species to grow, and when to harvest it, for halal-certified carotenoid production under standard, non-stressed conditions.

2. Materials and Methods

2.1. Microalgal cultivation

Nannochloropsis oculata, *Nannochloropsis oceanica* and *Chlorella vulgaris* were grown in Conway medium (pH 6.8) under 24-hour illumination from fluorescent lamps. We added no organic carbon, so growth was photoautotrophic, and the cultures received no nutrient deprivation or other stress. Samples were taken in biological triplicate (n = 3, three independent cultures) at four time points spread across the growth curve: Day 0 (inoculation), Day 7 (exponential phase), Day 10 (late exponential to early stationary phase) and Day 14 (stationary phase).

2.2. Metabolite extraction

Metabolites were extracted from freeze-dried biomass with a methanol:chloroform:water system. Carotenoids partition into the chloroform layer, so this layer was collected and dried down. The dried extract was saponified to remove chlorophylls and acylglycerol lipids and to hydrolyse any carotenoid esters, and was then analysed by LC-QTOF-MS/MS without derivatisation.

2.3. LC-QTOF-MS/MS analysis

The saponified extracts were run on LC-QTOF-MS/MS with reversed-phase separation in positive electrospray ionisation mode. Alongside the 12 biological samples of each species we injected a pooled quality control (QC) sample, made by combining all extracts, and a procedural blank, giving 14 injections per species. Sample material was limited, so each biological replicate was injected once without technical replicates, and instrument stability was followed through the pooled QC.

2.4. Data processing and putative identification

Raw data were processed in MS-DIAL (Tsugawa et al., 2015), and the spectra were searched against the MoNA full spectra library in positive mode. We then removed features without a metabolite name, features matched to NCGC synthetic library entries and features whose names ran longer than 45 characters. Where a compound appeared more than once, we kept the entry with the highest mean peak area.

Each carotenoid annotation was then checked against four criteria. The first was mass.

The measured *m/z* had to fall within 10 mDa of the calculated value for an expected carotenoid ion, meaning the radical cation ($M^{+\bullet}$), the protonated molecule ($[M+H]^+$) or the water-loss ion

([M+H−H2O]$^+$) (Rivera et al., 2014; Maoka, 2023). The second was retention time. On a reversed-phase column the polar xanthophylls elute first, lutein and zeaxanthin next and β-carotene last, so any feature with a xanthophyll mass that eluted after β-carotene was not assigned as a carotenoid. Third, the compound had to have been reported in that species (Lubián et al., 2000; Pantami et al., 2020; Sun et al., 2022; Caetano et al., 2024).

Fourth, we looked at detection frequency, using the MS-DIAL peak identifiers to see, sample by sample, whether a peak had really been detected or whether its area came from gap filling.

Features found in fewer than 4 of the 12 biological samples are reported as tentative.

Confidence levels follow Schymanski et al. (2014): Level 2 for library matches backed by MS/MS and Level 3 for putative assignments that rest on *m/z* and elution order. Isomers with the same molecular formula, such as lutein and zeaxanthin or violaxanthin and neoxanthin, give identical ions, so these criteria cannot separate them and we report them together.

2.5. Statistical analysis

Statistics followed the default MetaboAnalyst 6.0 workflow (Pang et al., 2024). Peak areas were normalised by sum, log10-transformed and auto-scaled. Principal component analysis (PCA) gave an unsupervised overview. Partial least squares discriminant analysis (PLS-DA) was then run in two ways: with species as the class for the cross-species comparison, and with growth phase as the class inside each species. We validated the models by leave-one-out cross-validation (R^2Y and Q^2) and 100-permutation tests and calculated variable importance in projection (VIP) scores by Wold's method. For each carotenoid we recorded how many replicates at each time point had the peak detected by MS-DIAL. Peak areas are given as the mean ± standard deviation of the detected replicates. When no replicate at a time point had the peak, that point is reported as not detected (n.d.), and no fold change was calculated against it. Differences between growth phases were tested by one-way analysis of variance (ANOVA; $n = 3$ per phase) on peak areas, with $p < 0.05$ taken as significant. For this test, samples below the detection threshold kept the area MS-DIAL had integrated at the expected m/z and retention time during gap filling, so all three replicates of each time point were included.

3. Results

3.1. Putative carotenoid identification

The MoNA library put names on 181 features in *N. oculata*, 136 in *N. oceanica* and

193 in *C. vulgaris*. Many of those names belonged to compounds we would not expect in microalgae, among them pharmaceuticals (gabapentin, nandrolone, tamoxifen), an industrial chemical (dibutylphthalate) and shellfish carotenoids such as crassostreaxanthin, and we excluded them. Once unnamed features, excluded matches, long-name entries and duplicates had been taken out, 80 unique named compounds were left for *N. oculata*, 43 for *N. oceanica* and 94 for *C. vulgaris*.

Table 1 lists the putative carotenoid assignments. Features that looked like carotenoids eluted between 10.0 and 12.2 min, in the order a reversed-phase separation would predict: violaxanthin-related ions at about 10.3 to 10.6 min, a lutein or zeaxanthin-related ion at 11.65 min and β-carotene at 12.0 to 12.2 min. The features the library called diadinochrome, at *m/z* 583.415, lay within 0.8 to 4.3 mDa of the water-loss ion of violaxanthin. Violaxanthin is the main xanthophyll of *Nannochloropsis* (Lubián et

al., 2000;

Sun et al., 2022), so we assigned them putatively as violaxanthin-related. At *m/z* 551.42 and

11.65 min, the library offered celaxanthin in *C. vulgaris* and echinenone in *N. oculata*, but both features matched the water-loss ion of lutein or zeaxanthin. In *C. vulgaris* this feature co-eluted with a zeaxanthin-labelled ion at *m/z* 568.425. In *N. oculata* we could not rule out echinenone, which has the same calculated mass. β-Carotene matches were kept and recorded as radical cations. Features at *m/z* 601.42, labelled nostoxanthin or a deuterated lipid standard, eluted after β-carotene and were therefore not assigned as carotenoids. Apart from β-carotene in *N. oculata*, every assignment stays at Level 3.

3.2. Cross-species separation

The PCA scores split the three species into separate clusters, with PC1 explaining 46.0% and PC2 33.3% of the total variance (Figure 2A). *C. vulgaris* (Chlorophyceae) sat on one side of PC1 and both *Nannochloropsis* species (Eustigmatophyceae) on the other, which is what the wide phylogenetic gap between the two classes, and their different pigment and lipid profiles, would lead one to expect (Pantami et al., 2020; Sun et al., 2022). PLS-DA gave the same picture, with R^2Y of 0.994 and Q^2 of 0.981 (Figure 2B), so the model both fitted the data and predicted held-out samples well (Pang et al., 2024).

3.3. Growth-phase effects on the whole metabolome

Inside each species, PLS-DA with growth phase as the class predicted poorly. *C.*

vulgaris did best, with a Q^2 of 0.068 (p = 0.010), while *N. oceanica* gave −0.169 and *N.*

oculata −0.216. A negative Q^2 means the model predicts worse than simply using the class average (Pang et al., 2024). Weak separation is not surprising here. Without stress, the metabolome drifts gradually from one sampling day to the next (Esteves et al., 2024), and three replicates per group is a small sample set against 43 to 94 features. The top VIP features in all three species were fatty acid amides and other lipid-related compounds, oleamide and erucamide among them, consistent with lipid storage building up as the cultures matured (Ambati et al., 2019). Carotenoids ranked lower. In *N. oculata*, for instance, β-carotene came 12th of 80 features (VIP = 1.20) and the 551.42 ion 16th (VIP = 1.17).

3.4. Carotenoid changes across growth phases

Individual carotenoid signals tracked the growth phases more clearly than the whole metabolome models did (Table 2, Figure 3). In *N. oculata*, β-carotene was missing from every Day 0 sample but present in all three Day 7 samples and in some later ones. Its mean peak area rose from 11.5×10^3 at Day 7 to 18.4×10^3 at Day 10 and stood at 16.3×10^3 at Day 14 (F = 9.54, p = 0.005). Carotenoids building up as growth slows would produce this pattern (Ambati et al., 2019; Duan et al., 2024). The zeaxanthin-related signal was detected in every sample at Days 7 and 10, with its highest mean peak area at Day 7 (75.8×10^3), and in none at Day 14 (F = 11.17, p = 0.003). A short-lived zeaxanthin peak during active growth fits the violaxanthin cycle at work (Lubián et al., 2000). The violaxanthin-related signal showed up in 11 of the 12 samples and hardly moved (mean peak area 62.4×10^3 to 83.9 ×

10^3, p = 0.75).

In *C. vulgaris*, the lutein or zeaxanthin-related signal appeared in one Day 0 sample and in every sample from Day 7 onwards, with mean peak areas of 38.5×10^3, 23.9×10^3 and

39.4×10^3 at Days 7, 10 and 14, against 9.0×10^3 in the one Day 0 replicate where it was detected (F = 7.01, p = 0.013). Lutein is the main carotenoid of this species (Pantami et al., 2020; Caetano et al., 2024). Still, lutein and zeaxanthin are isomers that give the same ions, and our method could not separate them, so we report the signal as lutein and/or zeaxanthin.

The violaxanthin or neoxanthin-related signal stayed flat ($p = 0.59$). β-Carotene turned up in only 3 of 12 samples, all from Days 10 and 14, and its change was not significant (p = 0.15), so we treat it as tentative. The same applies to *N. oceanica*, where the violaxanthin-related signal was detected in two Day 0 samples and in no later sample.

Table 1. Putative carotenoid assignments for features labelled as carotenoids by the MoNA library.

Species	MoNA label	Curated assignment	Ion	m/z	RT (min)	Δ (mDa)	Detected	Level
N. oculata	beta-Carotene Echinenone	β-Carotene Zeaxanthin (or	M+• [M+H−H2O]+ (or	536.4302 551.4226	12.21 11.65	−7.5 −2.2	6/12 7/12	2 3
	Diadinochrome	echinenone) Violaxanthin	[M+H]+) [M+H−H2O]+	583.4154	10.46	+0.8	11/12	3
	Nostoxanthin	Not assigned	—	601.4268	15.78	—	7/12	—
N. oceanica	Diadinochrome	(elutes after β-carotene) Violaxanthin	[M+H−H2O]+	583.4188	10.64	+4.3	2/12	3
C. vulgaris	beta-Carotene	(tentative) β-Carotene	M+•	536.4249	12.01	−12.7	3/12	3
	Celaxanthin	(tentative) Lutein (or	[M+H−H2O]+	551.4268	11.65	+2.1	10/12	3
	Diadinochrome	zeaxanthin) Violaxanthin or	[M+H−H2O]+	583.4178	10.46	+3.2	11/12	3
	LPC 19:0-d5	neoxanthin Not assigned (elutes after β- carotene)	—	601.4207	16.38	—	1/12	—

Note. Δ is the difference between the measured and calculated *m/z* of the assigned ion.

Detected is the number of the 12 biological samples in which MS-DIAL detected the peak rather than estimating its area by gap filling. Level is the Schymanski et al. (2014) confidence level. The zeaxanthin water-loss ion and protonated echinenone share the same calculated *m/z* (551.4247). RT = retention time.

Table 2. Peak areas ($\times 10^3$) of carotenoid signals at each growth phase.

Species	Compound	Detected (D0/D7/D10/ D14)	Day 0	Day 7	Day 10	Day 14	F	p
N. oculata	β-Carotene Zeaxanthin-related ion	0/3/2/1 1/3/3/0	n.d. 51.0	11.5 ± 7.5 75.8 ± 8.5	18.4 ± 1.2 46.4 ± 18.7	16.3 n.d.	9.54 11.17	0.005 0.003
	Violaxanthin-related	2/3/3/3	83.9 ±	81.2 ± 8.1	69.6 ± 0.9	62.4 ± 9.5	0.41	0.751

N. oceanica	ion Violaxanthin-related	2/0/0/0	43.6 20.5 ± 2.5	n.d.	n.d.	n.d.	36.41	< 0.001
C. vulgaris	ion (tentative) Lutein and/or	1/3/3/3	9.0	38.5 ± 17.8	23.9 ± 4.3	39.4 ± 7.1	7.01	0.013
	zeaxanthin-related ion Violaxanthin/	3/2/3/3	9.8 ± 3.6	16.6 ± 9.5	14.4 ± 5.1	14.7 ± 0.8	0.69	0.585
	neoxanthin-related ion β-Carotene (tentative)	0/0/1/2	n.d.	n.d.	24.4	21.5 ± 1.2	2.30	0.154

β-Carotene (tentative) 0/0/1/2 n.d. n.d. 24.4 21.5 ± 1.2 2.30 0.154 Note. Values are mean ± standard deviation of the replicates in which MS-DIAL detected the peak; a single value without standard deviation means the peak was detected in only one replicate, and n.d. means it was not detected in any of the three replicates. Detected gives the number of the three biological replicates at Days 0, 7, 10 and 14 in which the peak was detected. *F* and *p* are from one-way ANOVA across the four growth phases on the integrated peak areas of all three replicates. Tentative signals were detected in fewer than 4 of 12 samples.

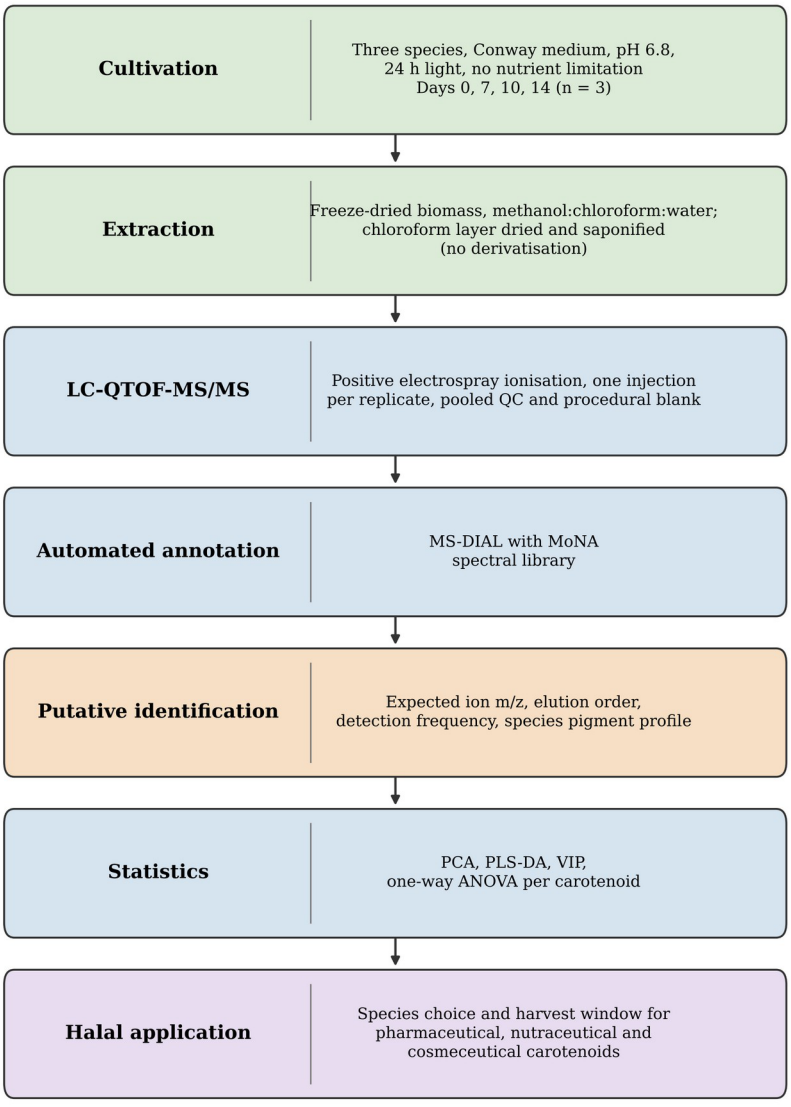

Figure 1. Study workflow, from cultivation to halal application.

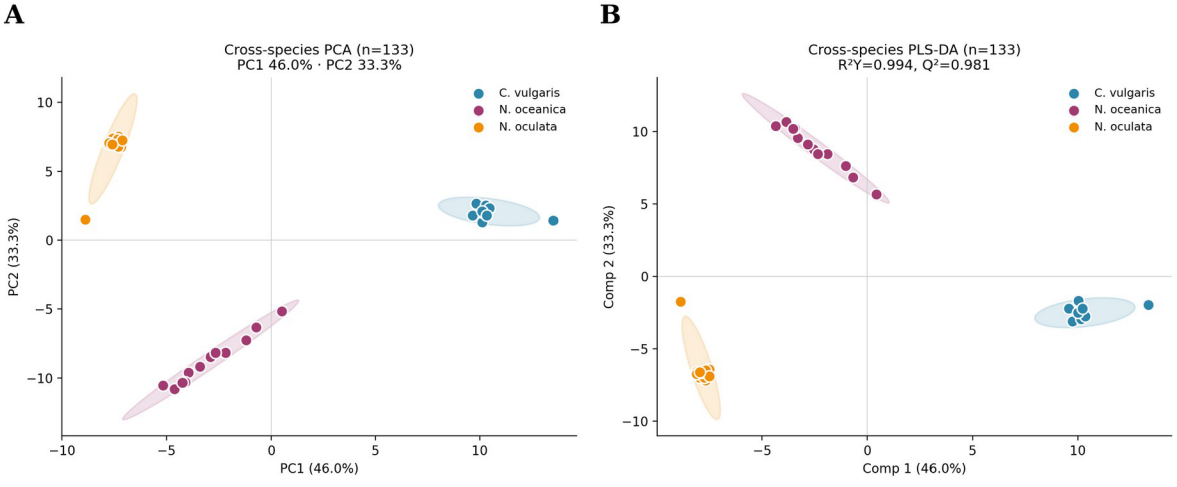

Figure 2. Cross-species separation of the three microalgae. (A) PCA scores plot. (B) PLS-DA scores plot.

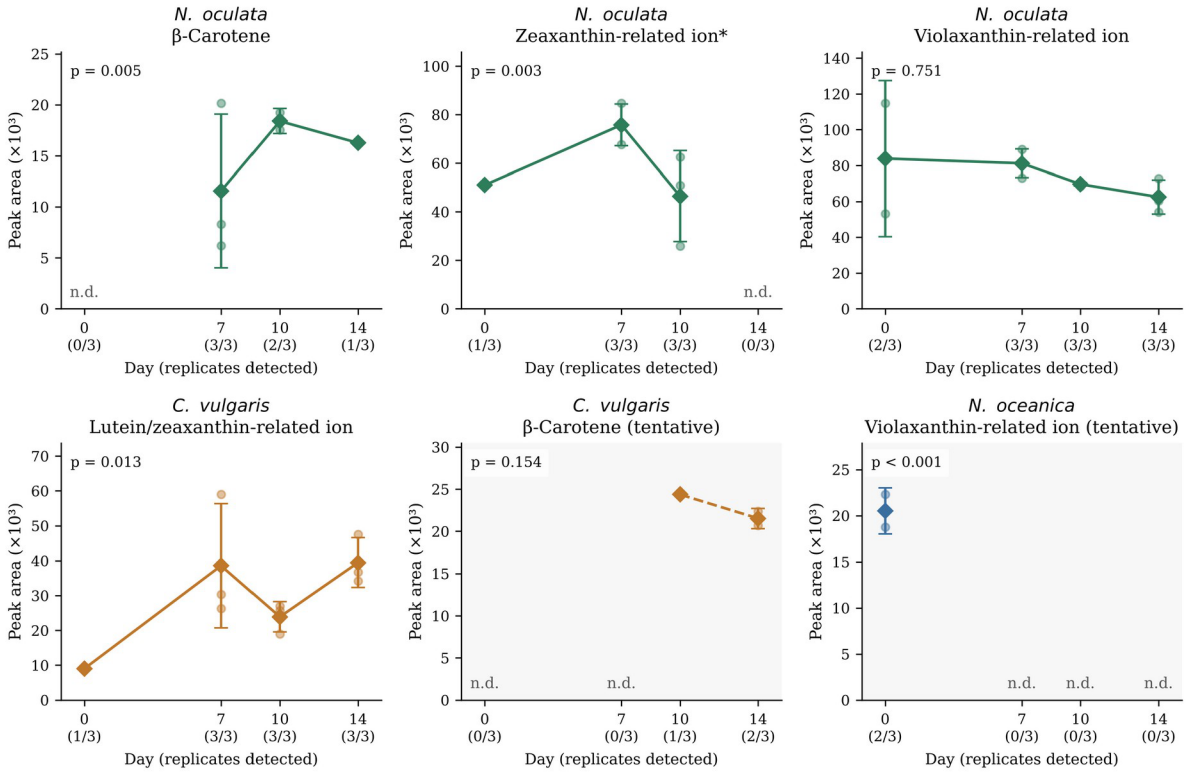

Figure 3. Carotenoid signals across growth phases. Diamonds show the mean peak area of the replicates in which the peak was detected, with standard deviation bars where at least two replicates were detected, and circles show the individual detected replicates. The numbers under each day give how many of the three replicates had the peak detected. n.d. marks days on which no replicate had the peak. Dashed lines on grey panels are tentative signals detected in fewer than 4 of 12 samples. The zeaxanthin-related ion in ∗ *N. oculata* may include echinenone.

4. Discussion

4.1. Microalgal carotenoids for the halal market

These cultures were grown normally rather than under stress, so the data show what a facility would get from an ordinary batch run. Nitrogen limitation, high light and similar stress treatments are widely used to push carotenoid content up (Ambati et al., 2019; Duan et al., 2024). We did not include them, so our results describe baseline production and cannot tell how a non-stressed harvest compares with a stress-induced one. The clearest result came from *N. oculata*, where β-carotene, absent at Day 0, was present from Day 7 and highest at Day 10 under standard cultivation conditions. Microalgal β-carotene is valued as a provitamin A source and an antioxidant in nutraceutical and cosmeceutical products (Duan et al., 2024). In *C. vulgaris*, a lutein and/or zeaxanthin signal rose by Day 7 and stayed up. Both pigments are sold widely in eye-health supplements (Fu et al., 2023), a category where halal certified, animal-free formulations are sought after (Wan Sulaiman et al., 2023). Violaxanthin has anti-inflammatory and cosmeceutical potential (Garg et al., 2024; Dutta et al., 2023). Its signal changed

little with growth phase in either *N. oculata* or *C. vulgaris*, so it could be collected as a co-product whatever the harvest day.

Microalgae grown in mineral media contain nothing of animal origin, and their pigments can be recovered with solvents and methods that halal guidelines accept (Wan Sulaiman et al., 2023; Herdiana et al., 2024). Unlike synthetic carotenoids, they offer a natural, plant-based origin, and that counts in halal markets where clean-label expectations are rising (Garg et al., 2024; Mekinić et al., 2023). The halal cosmetics market alone is forecast to reach USD 143 billion by 2034 (Fortune Business Insights, 2025), and carotenoid based sun-care and anti-ageing products have an obvious place in it (Dutta et al., 2023).

4.2. Putative identification of carotenoids

We had no authentic standards, so the carotenoids in this study were identified putatively, mostly at Level 3 (Schymanski et al., 2014), from the *m/z* of their expected ions.

In positive electrospray a carotenoid may appear as a radical cation, a protonated molecule or a water-loss ion (Rivera et al., 2014; Maoka, 2023), and we read these ion forms together with elution order, detection frequency and the published pigments of each species. The library names served as a starting point. We replaced them where a carotenoid known from the species matched the measured mass and retention time. Lutein and zeaxanthin share an exact mass and fragment in much the same way, so these checks cannot tell them apart, and we report such signals as lutein and/or zeaxanthin (Rivera et al., 2014; Maoka, 2023). The approach gives a fair view of which carotenoids are present and how they shift with growth phase. Before any of these assignments are used in halal ingredient documentation, though, they should be confirmed by high-performance liquid chromatography with authentic standards (Wan Sulaiman et al., 2023; Todorović et al., 2022).

4.3. Harvest timing for halal carotenoid production

Each species responded to growth phase in its own way. In *N. oculata*, β-carotene built up from Day 7 and levelled off from Day 10, while the zeaxanthin-related signal peaked at Day 7 and had disappeared by Day 14. A harvest between Days 7 and 10 would therefore catch β-carotene near its highest while zeaxanthin is still there. In *C. vulgaris*, the lutein and/or zeaxanthin signal was already high at Day 7 and stayed high to Day 14. That leaves a wide harvest window, which can be set by biomass yield instead. Other studies have also seen carotenoid profiles change with culture age in the absence of stress (Lubián et al., 2000;

Rajput et al., 2022; Caetano et al., 2024), but whether harvest timing alone can come close to stress-based yields needs a direct comparison under the same conditions (Duan et al., 2024).

These recommendations hold for Conway medium under continuous light, and they should be checked at pilot scale with quantitative high-performance liquid chromatography and authentic standards (Rivera et al., 2014; Todorović et al., 2022).

4.4. Limitations

Without authentic standards, most assignments remain at Level 3 (Schymanski et al., 2014). The water-loss ions cannot separate lutein from zeaxanthin or violaxanthin from neoxanthin, and in *N. oculata* echinenone cannot be ruled out. Separating these isomers would need better chromatography,

for example a C30 column, together with authentic standards (Rivera et al., 2014; Maoka, 2023). Vaucheriaxanthin was not assigned. An ion at *m/z* 599.41 eluting at 10.0 min in both *N. oculata* and *C. vulgaris* may come from a C40H56O5 xanthophyll, but we could not identify it. We did not include stress treatments, so carotenoid output under standard and stress conditions cannot be compared here. Each extract was injected only once because sample material was limited, and technical variation was tracked only through the pooled QC. Saponification removes chlorophylls and lipids that would otherwise interfere, but it may also cause some loss of alkali-sensitive xanthophylls, so their peak areas could be underestimated. The *N. oceanica* signal and the *C. vulgaris* β-carotene signal were detected too rarely to support firm conclusions. Growth phases were set by sampling day, not by measured cell density. One *N. oculata* Day 0 replicate also gave near zero values for most compounds, probably because there was little biomass at Day 0 (optical density 0.6).

5. Conclusion

We followed the metabolomes and carotenoid signals of three microalgae across their growth curve under normal cultivation. Species identity shaped the metabolome far more than growth phase did, but growth phase still moved individual carotenoids. In *N. oculata*, β-carotene appeared from Day 7 and peaked at Day 10, with a brief zeaxanthin-related peak at Day 7. *C. vulgaris* showed a lutein and/or zeaxanthin signal that rose by Day 7 and stayed high, and violaxanthin-related signals held steady in both species. All of these identifications are putative, resting on the *m/z* of expected ions together with elution order and known pigment profiles, and our next step is to confirm them with authentic standards. Stress treatments were not tested, so the findings describe baseline production under standard conditions, and a direct comparison with stress-based cultivation is needed before harvest timing can be weighed against stress induction. Microalgae grown in defined mineral media are halal-compliant by nature and make carotenoids with established pharmaceutical, nutraceutical and cosmeceutical uses (Garg et al., 2024; Dutta et al., 2023; Mekinić et al., 2023). That makes them a practical, natural source of bioactive ingredients for a growing halal market (Wan Sulaiman et al., 2023).

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(O-33) SHARIAH BOUNDARIES OF PHARMACEUTICALS WITH NON-HALAL INGREDIENTS

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Abstract

The research paper titled “Shariah Boundaries of Pharmaceuticals with Non-halal Ingredients”, explores the intersection of pharmaceuticals and nutraceuticals within the framework of contemporary scenarios and Shariah concessions in the light of OIC/SMIIC Halal Pharma Standards. The paper delves into the multifaceted challenges and considerations faced by the pharmaceutical and healthcare industries in producing Halal products for the Muslim population.

Where pharmaceuticals and nutraceuticals are fundamental to human well-being, the paper investigates the nuanced status of medication within Islam. It elucidates the diverse categories of pharmaceutical products from life-saving drugs to nutraceuticals, evaluating their adherence to Shariah rulings. The study examines specific scenarios of R & D for Non-halal Product and production of non-Halal pharmaceuticals, like Heparine. The research explores the usage of Alcohol, Gelatin, Shellac, Animal-derived ingredients, Pork and its by-products, Blood and blood products and Intoxicating agents in pharmaceutical manufacturing and addresses whether changes in nature (Istihala) occur during the pharmaceutical production processes. It debates Ritual cleansing, Production line change method and Contamination issue between Halal and non-halal production.

This study examines the Shariah rulings regarding biological drugs derived from genetically engineered cell lines sourced from non-halal animals, such as CHO (Chinese hamster ovary) cells. It also examines human erythropoietin hormone, which is derived from humans and increases red blood cell (RBC) production. Due to advances in biotechnology, this hormone can be expressed and produced in CHO cell lines and purified to ensure that no CHO components remain in the final product. Furthermore, the paper explores the boundaries of medication containing non-Halal ingredients or intoxicating agents and scrutinizes various modes of drug administration through a Shariah lens under extreme conditions, including oral administration, inhalation (MDI), and intramuscular injection, absorption through the skin, intravenous injection, and external use.

Methodologically, the study is grounded in a practical case study of a Halal-certified pharmaceutical manufacturer operating in accordance with OIC/SMIIC Halal Pharma Standards. The case study also examines non-Halal manufacturing within the facility and the responsibilities of the Halal certification body, including the direct supervision of non-Halal manufacturing processes, auditing and monitoring compliance with established procedures, verifying the segregation of Halal and non-Halal production activities, materials, and equipment, and monitoring contamination-prevention measures to prevent cross-contamination between Halal and non-Halal production. This practical case study provides a basis for analysing the relevant Shariah rulings and production-related challenges.

The study adopts a Shariah-based analytical, qualitative approach, applying the principles of necessity and critical need (ضرورة، حاجة، اضطرار), Istihala, and اهون البليتين (the lesser of the two evils) and

Shariah quantitative approach in harmful substances (الضرر) to the selected pharmaceutical and nutraceutical cases and production scenarios.

It also considers OIC/SMIIC Global Halal Pharma and GMP, GHP, and GLP standards, through theoretical analysis and practical case studies. The scope is confined to the Shariah assessment of pharmaceuticals and nutraceuticals containing non-halal or potentially non-halal ingredients, the biological drugs involving CHO cell lines, the specified modes of drug administration, and the selected production and processing issues, including ritual cleansing, production line change methods, and contamination between Halal and non-halal production. The study focuses on the Shariah boundaries of permissibility rather than providing a clinical or therapeutic evaluation of the medicines.

This research is limited solely to the pharmaceutical sector; the status of Halal or Haram in food and beverage sectors not its subject.

The research contemplates the responsibilities of stakeholders including Shariah scholars, pharmacists, manufacturers, consumers, and regulators, specially the responsibility regarding research and discover the Halal alternatives of Haram ingredients. The paper contributes to a comprehensive understanding of the complexities involved in producing and consuming Halal and (permissible) non-halal pharmaceuticals and nutraceuticals.

The paper employs a research methodology rooted in the analysis of global Halal, food safety, and quality management standards, both theoretically and practically. It provides valuable insights into the Shariah perspective on various pharmaceutical and nutraceutical products, offering guidance to industries striving to align their practices with Islamic principles. As the Muslim population seeks awareness and access to Halal pharmaceuticals and nutraceuticals, this research contributes to the ongoing dialogue surrounding the ethical production and consumption of these crucial products.

Keywords: Shariah Concessions, Life-saving Drugs, Heparin, Shellac, CHO (Chinese hamster ovary), Human Erythropoietin Hormones.

(O-34) THE RECOGNITION OF LHLN CERTIFICATES REQUIRES ENSURING THAT OVERSEAS PRODUCERS ADHERE TO INDONESIAN HALAL STANDARDS

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Abstract

Producers of halal products are making progressive strides in countries with Muslim minority populations (Dinar Standard, 2025). Manufacturers in Europe and the Americas export halal products to Muslim majority nations, including Indonesia. To streamline the cross-border halal certification process, the Indonesia's halal certification authority (BPJPH) employs an approach involving the recognition of halal certificates issued by Foreign Halal Agencies (LHLN). As of mid 2026, BPJPH maintains halal certificate recognition agreements with 115 LHLNs across 37 countries. Products certified by an LHLN may enter Indonesia without requiring re certification domestically. In reality, however, the halal integrity of all foreign products entering Indonesia is not yet fully guaranteed; instances of imported products containing pork circulating in various regions of Indonesia have been identified. Recent findings from 2025 revealed nine types of processed food products containing pork derivatives. This study aims to formulate policy recommendations for BPJPH regarding the recognition of certificates issued by LHLNs. A qualitative analysis approach was employed, utilizing SWOT analysis to map the strengths, weaknesses, opportunities, and threats associated with the implementation of LHLN certificate recognition. The research results indicate a lack of assurance regarding the halal compliance of products entering Indonesia. The analysis revealed potential misuse of LHLN halal certificates specifically, instances where certificates did not correspond to the actual products such as mismatches regarding the product's origin or country of import, as well as discrepancies in product identity, manufacturer details, production facilities, and certification scope. LHLNs partnering with BPJPH often lack domestic oversight systems capable of ensuring that producers maintain measurable internal control systems. Consequently, halal certification by overseas producers appears driven more by trade requirements than by a genuine commitment to halal product assurance. The research recommends ensuring that producers whose products are certified by LHLN adhere to Indonesian halal standards. This ensures the halal integrity of products shipped to Indonesia prior to their commercialization in the country.

Keywords: halal products, LHLN, halal certificate recognition, halal product assurance, BPJPH

1.Introduction

Rapid growth of global demand for halal products shows projection on the halal industry is about to become one of the important pillars of global economic growth in the coming years (Rahman, 2020). Recognition of foreign halal certificates is a strategic instrument for strengthening the national halal ecosystem. Through mutual recognition mechanisms, the registration of foreign halal products can be carried out more efficiently without compromising legal certainty regarding product halal assurance. In practice, recognition of foreign halal certificates also faces various challenges, such as differences in halal standards between countries, the capacity of halal certification bodies, economic diplomacy,

and the need to harmonize regulations and conformity assessment systems. A key issue in the era of globalization is the implementation of free markets, which have spread throughout the world. The halal food industry in secular countries and countries with Muslim minorities is growing and has prospects in the global market (Bahrudin et al., 2024).

The continued global growth of halal product trade means that Indonesia must regulate not only the halal certification of domestic products but also the acceptance of halal certificates issued by Foreign Halal Institutions (LHLN). Differences in institutional arrangements, standards, audit methods, slaughtering practices, laboratory testing, and interpretations of Sharia provisions may create challenges in ensuring equivalent halal product assurance. The legal basis for recognizing foreign halal product certificates is Government Regulation (PP) No. 42 of 2024 concerning the Implementation of Halal Product Assurance (JPH). This regulation stipulates that the body authorized to administer JPH in Indonesia is the Halal Product Assurance Organizing Agency (BPJPH).

This regulation stipulates that, in principle, foreign products entering Indonesia must be halal-certified. Halal certificates for products subject to mandatory halal certification may be issued by LHLN. Recognition of certificates issued by LHLN is carried out through cooperation with BPJPH. Article 142 of PP No. 42/2024 provides that international cooperation in JPH is conducted through mutual acceptance agreements for halal certificates between BPJPH and LHLN. An LHLN must be established by a government or an Islamic religious institution recognized by the relevant country, accredited by an accreditation body in its country of origin that is recognized within a regional or international accreditation cooperation organization, and subsequently accredited by BPJPH. Only after these steps is an MRA signed by the head of the LHLN and the head of BPJPH.

Monitoring by BPJPH and the National Agency of Drug and Food Control (BPOM) of imported products circulating in Indonesia has identified products that do not comply with halal product assurance requirements. The latest findings in 2025 involved nine processed food products containing pork-related components, as confirmed by laboratory testing. Investigations at the production sites found a common issue: pork gelatin raw materials were used, while the accompanying documents labeled them as halal-certified bovine gelatin. This indicates that possession of a halal certificate does not fully guarantee consistency between the halal certificate documentation and the products being traded (BPJPH, 2025).

In 2024, a case was also found involving beef imported from the United States. During inspections at seven company locations in the United States, the cattle were found to have been slaughtered in a manner that did not comply with Islamic law. Another widely publicized case occurred in 2017, when BPOM issued a press release on 18 June 2017 concerning the withdrawal of Korean instant noodle products containing pork. Based on sampling and testing for pork specific DNA, four instant noodle products tested positive for pork DNA. Another issue of concern was inaccurate information on product labels. BPOM stated that the products testing positive did not carry the warning “Contains Pork” on their labels. However, the importer had not informed BPOM during registration that the products contained pork-derived ingredients, leading to an order to withdraw the products from circulation.

Research by Indriyani et al. (2025) indicates that MRAs have the potential to simplify cross border certification, avoid duplicated inspections, and improve trade efficiency. LHLN must undergo an assessment process and meet the requirements established by BPJPH. This is important for maintaining equivalent standards and protecting Indonesian consumers. Recognition aims to simplify procedures because products already certified by a recognized LHLN do not need to apply again for

Indonesian halal certification.

BPJPH explained that importers submit registrations electronically by attaching documents such as the LHLN halal certificate, a letter of appointment from the manufacturer, the importer's/representative's Business Identification Number (NIB), a list of goods and HS codes, and legalization or apostille documents as required. After verification, payment, and approval, BPJPH issues a registration number for the foreign halal certificate (BPJPH, 2024). BPJPH reported the signing of MRAs with 37 LHLN, comprising nine LHLN at the recognition and mutual acceptance stage and 28 LHLN covered by agreements to accelerate completion of assessments. The BPJPH Performance Report in 2025 recorded MRAs with 31 countries, including Italy, Australia, Germany, Spain, China, South Korea, the United Kingdom, Lithuania, New Zealand, the Philippines, South Africa, and Russia.

Research examining Mutual Recognition Agreements (MRAs) as an instrument to facilitate cross-border halal certification was conducted by Manthovani et al. Its main focus was how MRAs can reduce duplication in certification processes and improve the efficiency of halal product trade.

MRAs have the potential to simplify cross-border certification, but their effectiveness continues to face challenges arising from differing interpretations of Sharia, unequal testing infrastructure, and inter-institutional coordination issues (Manthovani et al., 2025). The literature review found no studies specifically addressing the implementation of Indonesia's policy on recognition of LHLN halal certificates or the compliance of overseas manufacturers with Indonesian halal standards. This study aims to formulate policy recommendations for BPJPH concerning the recognition of halal certificates issued by LHLN.

2.Methods

This study combines a literature review, SWOT analysis, and the Analytic Network Process (ANP) to formulate policy recommendations for recognizing halal certificates issued by Foreign Halal Institutions (LHLN). Secondary data were obtained from BPJPH and relevant literature, while primary data were collected through in-depth interviews with stakeholders involved in foreign halal certificate recognition. SWOT analysis was used to identify internal and external factors affecting the recognition process, while ANP examined the interrelationships and relative priorities of these factors (Teoli, et al., 2023; Saaty, 2013). ANP was selected because it allows policies involving relevant stakeholders to be interrelated and mutually influential (Saaty, 2013).

The ANP procedure involved problem identification, the determination of criteria and alternatives, network construction, and expert pairwise comparisons using a 1–9 scale. The resulting judgments were processed into an unweighted supermatrix and a weighted supermatrix, which was iteratively raised to successive powers until convergence was achieved. The resulting limit supermatrix provided priority weights for formulating recommendations based on the highest-ranked alternatives (Saaty, 2013).

3.Results

BPJPH began providing LHLN certificate registration services in 2024. By early October 2026, reported that 13,464 halal certificates had been registered, covering 277,773 recorded products. The trend in LHLN certificate registrations in 2026 is shown in Figure 1.

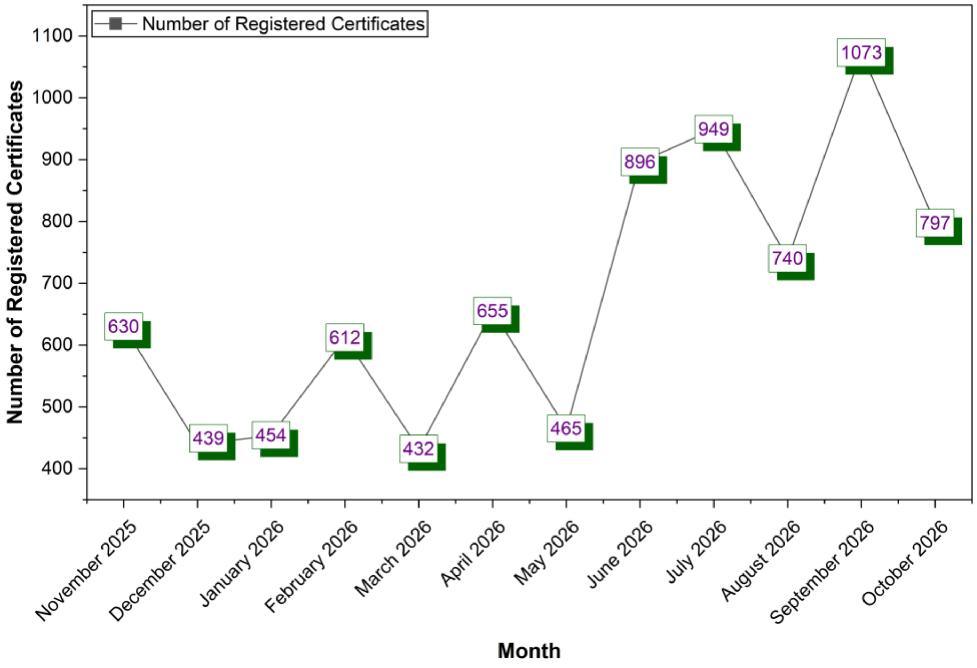

Figure 3.1 Amount of halal certificate registered through LHLN from November 2025 to October 2026

As shown in the figure above, the number of applications to register LHLN halal certificates in Indonesia is increasing. The number of product names listed on a single halal certificate also varies considerably, ranging from five product names to more than 1,000 product names on one certificate. The ratio of the number of LHLN certificates to the number of recorded product names, i.e. 20.63, indicates substantial variation in the number of product names covered by each LHLN halal certificate.

Interviews with BPJPH stakeholders indicated that discrepancies are frequently found between information on LHLN halal certificates registered with BPJPH and information documented in the MRAs. A summary of these discrepancies is presented in Table 3.1.

Table 3.1 Summary of discrepancies identified in LHLN certificates

No.	Item	Expected data in the LHLN certificate recorded in the MRA with BPJPH	Discrepancy identified
1	Product type	food	chemical product
		chemical product	medicine
		beverage	food
		medicine	chemical product
		genetically engineered product	chemical product
		biological product	medicine
2	Country where the LHLN is located	Belgium	Spain
		Italy	Belgium
		Germany	France
		Austria	United Kingdom

3	Production location	Beijing	Shenzhen
		Shanghai	Beijing
		Seoul	Andong
		Dublin	London
		Vienna	Madrid
		Guangzhou	Nanjing
	Standard used	SJPH	Other standards that do not comply with Indonesian standards

4.Discussion

The findings indicate low compliance by imported products with Indonesian halal standards.

The first cause is overseas manufacturers' non-compliance with the implementation of the Halal Product Assurance System (SJPH). Their primary objective is to ensure that their products can be exported to Indonesia, while implementation of Indonesian halal standards is not prioritized. This is indicated by findings that registered LHLN halal certificates do not match the data recorded in the MRAs between LHLN and BPJPH. Based on the analysis, the causes of these discrepancies are presented in Table 4.1.

Table 4.1 Causes of discrepancies in LHLN certificate registration data

Item	Cause of discrepancy
Validity of halal certificate	The product labeled as halal has not undergone halal certification
Data on halal-certified products (product type, production location data, name of the LHLN country)	Product data in the documents attached to the halal certificate differ from the product data that should be documented in the MRA
LHLN conducts halal certification using multiple standards	The products shipped do not comply with Indonesian halal standards
LHLN does not have a monitoring and oversight system for halal product assurance after a halal certificate has been issued	LHLN consider a monitoring and oversight system unnecessary because the halal-certified products are not intended for their own country
LHLN does not have a data system integrated with BPJPH's system	The BPJPH service team has difficulty validating halal product data registered with BPJPH

From the table above, the second aspect concerns the integrity of LHLN in issuing halal certificates. Discrepancies are generally found in halal certificates issued by private institutions/companies. Private LHLN partnered with BPJPH lack adequate monitoring systems in their countries to ensure that manufacturers implement measurable internal control systems.

Consequently, halal certification by overseas manufacturers appears to be driven primarily by trade demands. In addition, not all LHLN prepare product data for halal-certified products that are integrated with BPJPH. This is one of the obstacles to validating the authenticity of LHLN halal certificate data.

The analysis of primary data identified two alternative recommendations with the highest scores: the establishment of a mechanism to verify the conformity of imported products with the corresponding LHLN halal certificate documents, and the reassessment of the implementation of halal certificate recognition policies through Mutual Recognition Agreements (MRAs) between BPJPH and LHLN, which should be accompanied by reciprocal acceptance of halal certificates.

These recommendations address two interconnected issues: ensuring the conformity of imported products with their halal certification documents and ensuring that mutual recognition arrangements

provide reciprocal benefits for Indonesian halal-certified products.

Based on this research discovery, the authors recommend establishing a mechanism to ensure the conformity of imported products entering Indonesia by checking whether LHLN certificate documents match the goods imported into Indonesia. This is intended to ensure that manufacturers whose products are certified by LHLN comply with Indonesian halal standards.

Such assurance is expected to safeguard the halal integrity of products shipped to Indonesia before they are marketed domestically. The Government Regulation provides for recognition of certificates issued by LHLN through MRAs, which stipulate that international cooperation in JPH is conducted through mutual acceptance agreements for halal certificates between BPJPH and LHLN. In practice, however, there is no reciprocal agreement ensuring that Indonesian products are accepted by countries whose LHLN are recognized by Indonesia. Accordingly, Indonesia's policy implementation concerning recognition of LHLN halal certificates also needs to be reviewed.

5.Conclusion

The findings show that imported products entering Indonesia have low compliance with Indonesian halal standards with stem caused from two aspects: overseas manufacturers and LHLN.

Manufacturers tend to prioritize meeting trade requirements to access the Indonesian market rather than consistently implementing the SJPH. The need to strengthen mechanisms for verifying the consistency of halal certificate documents with imported products entering Indonesia is shown in order to ensure halal integrity before the products are marketed. Implementation of Article 142 of Government Regulation No. 42 of 2024 should be evaluated, particularly regarding the effectiveness of MRAs in ensuring equivalent standards and the principle of mutual acceptance.

Accordingly, the policy for recognizing LHLN halal certificates should focus on strengthening oversight, data transparency, institutional accountability, and equality in trade benefits. It is important to ensure that recognition of halal certificates does not merely facilitate access for foreign products to the Indonesian market, but also protects Muslim consumers and strengthens the competitiveness of Indonesian halal products in the global market.

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(O-35) BEYOND CERTIFICATION COSTS: A CONTEXT-SPECIFIC SUPPORT FRAMEWORK FOR HALAL FOOD SMALL AND MEDIUM ENTERPRISES (SMES) IN KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

The expansion of the global Halal economy offers significant opportunities for small and medium-sized enterprises (SMEs) in developing countries. However, obtaining Halal certification does not automatically enable small businesses to benefit from certified markets. Financial constraints, limited technical expertise, complex documentation, inadequate awareness of Halal standards, and insufficient institutional support may prevent SMEs from obtaining certification, maintaining compliance, and accessing wider markets. Although these challenges have received considerable attention in existing literature, further context-specific investigation is needed to understand how certification support mechanisms can be integrated to improve SME competitiveness in Pakistan, particularly in Khyber Pakhtunkhwa (KP). This conceptual paper proposes a Halal SME Support Framework for food-sector SMEs in Khyber Pakhtunkhwa. Drawing on relevant literature concerning Halal certification, SME development, food-safety standards, and institutional support, the paper conceptualizes certification as a staged process involving certification readiness, continuing compliance, and market development. The proposed framework integrates four mechanisms: targeted financial assistance, shared technical advisory and capacity-building services, simplified and digitally supported certification guidance, and institutional coordination to improve market linkages. Unlike approaches that treat certification barriers as isolated problems, the framework emphasizes the interaction between financial resources, organizational capabilities, certification procedures, and access to commercial opportunities. The paper also proposes an empirical validation phase involving SMEs and Halal certification stakeholders in Khyber Pakhtunkhwa. Structured questionnaires and semi-structured interviews will be used to examine the relevance of the identified barriers and assess the perceived usefulness of the proposed interventions. The resulting evidence will be used to refine the framework and develop context-sensitive recommendations. The paper contributes a locally focused conceptual approach that connects certification accessibility with compliance sustainability and market participation. Its practical implications concern the design of more accessible, coordinated, and commercially relevant Halal certification support programs for SMEs.

Keywords: Halal Certification, Small and Medium-Sized Enterprises, Khyber Pakhtunkhwa, Pakistan, Halal Food Industry, Institutional Support, SME Competitiveness, Market Access.

1. Introduction

The global Halal economy has developed beyond its traditional association with food products and now encompasses several interconnected industries, including pharmaceuticals, cosmetics, logistics,

tourism, and other consumer services. Within this expanding economic environment, Halal certification serves as an important mechanism for demonstrating conformity with applicable Halal requirements and strengthening confidence among consumers and commercial partners.

Small and medium-sized enterprises play an important role in local economic development, employment generation, entrepreneurship, and the supply of food products. In developing economies, these businesses can contribute to economic diversification and provide opportunities for local producers to enter more organized markets. Nevertheless, the ability of SMEs to participate in the certified Halal economy may be constrained by their financial resources, technical expertise, administrative capacity, and access to relevant institutions.

Halal certification involves more than obtaining a certificate. Depending on the applicable certification scheme and the nature of a business, enterprises may need to demonstrate appropriate ingredient sourcing, production practices, traceability, hygiene arrangements, recordkeeping, and procedures for maintaining conformity. Businesses must also understand the applicable requirements and respond to certification-related documentation, assessment, and follow-up obligations.

These responsibilities may be particularly challenging for small businesses that operate with limited staff, informal management systems, and restricted financial resources. While larger enterprises may be better positioned to employ dedicated compliance personnel or obtain specialist advice, smaller firms may have to manage certification requirements alongside their daily production and commercial activities.

Pakistan provides a relevant context for examining these challenges. Its food sector includes a wide range of businesses involved in food processing, manufacturing, packaging, distribution, and retail. Khyber Pakhtunkhwa is particularly relevant as a setting for investigating the needs of SMEs operating within local food markets and exploring the institutional arrangements that could support their participation in certified Halal markets.

Pakistan has established national standards based on the OIC/SMIIC framework, including standards relating to Halal food and requirements for bodies providing Halal certification. These standards provide an important formal foundation for certification and conformity assessment (Pakistan Standards and Quality Control Authority [PSQCA], n.d.).

However, the existence of standards does not necessarily mean that all SMEs possess the knowledge, resources, and organizational capacity needed to implement them effectively. It is therefore important to consider not only the requirements of certification but also the practical support businesses need to comply with those requirements and benefit from certification.

This paper develops a conceptual framework to address that issue. It proposes that Halal certification support should be organized around three connected stages: preparing businesses for certification, helping them maintain compliance, and enabling them to translate certification into meaningful market opportunities.

2. Problem Statement

Research on Halal certification has identified several challenges faced by SMEs, including certification expenses, limited awareness, procedural complexity, and insufficient technical

capabilities. These concerns are important, but repeatedly identifying them does not fully explain how support should be organized or which combinations of interventions may be most useful in a particular institutional and economic setting.

The problem is especially relevant to SMEs that lack dedicated quality-assurance personnel and established administrative systems. Even when a business recognizes the potential value of Halal certification, it may struggle to interpret applicable requirements, maintain records, identify suitable suppliers, or implement the procedures necessary to demonstrate conformity. These difficulties may affect both initial certification and the ability to maintain compliance over time.

A further concern is that certification and business competitiveness are related but distinct matters. Obtaining certification may help a business demonstrate compliance and strengthen market credibility, but commercial success also depends on product quality, pricing, packaging, distribution, customer relationships, and access to buyers. Certification support programs that concentrate exclusively on obtaining certificates may therefore overlook the additional capabilities required to benefit from certified markets.

The central problem addressed by this paper is the absence of a sufficiently integrated, contextspecific support approach that connects certification readiness, continuing compliance, and market development for Halal food SMEs in Khyber Pakhtunkhwa.

The paper addresses this problem by developing a conceptual framework that combines financial, technical, procedural, and institutional interventions. The framework is intended to provide a structured basis for subsequent field research and policy development rather than to claim that a particular intervention has already been proven effective in the province.

3. Research Objectives

The main objective is to develop a context-specific conceptual framework for improving access to Halal certification and supporting the competitiveness of food-sector SMEs in Khyber Pakhtunkhwa, Pakistan.

The specific objectives are:

1.To identify and organize the principal financial, technical, procedural, and institutional challenges associated with Halal certification for SMEs.

2.To examine how certification readiness, continuing compliance, and market development are connected. 3.To develop a support framework integrating financial assistance, technical guidance, simplified procedures, and institutional coordination. 4.To propose research propositions that can be tested through subsequent field research involving SMEs and Halal certification stakeholders.

5.To provide practical recommendations for policymakers, certification bodies, and SME support institutions.

4. Research Questions

The paper addresses the following research questions:

1.What financial, technical, procedural, and institutional factors may constrain Halal certification

among food-sector SMEs in Khyber Pakhtunkhwa? 2.How can support mechanisms be organized to address both initial certification and continuing compliance?

3.What role might technical training, documentation support, and digital guidance play in improving SME certification readiness? 4.How can coordination between SMEs, certification bodies, government institutions, and commercial buyers support participation in certified markets?

5.What indicators should be used to evaluate the proposed support framework in subsequent empirical research?

5. Literature Review

5.1 Halal certification and business confidence

Halal certification provides a formal mechanism for assessing whether relevant products and processes conform to applicable Halal requirements. It can help businesses communicate compliance to consumers and buyers, particularly where customers cannot independently verify all ingredients, processing arrangements, or supply-chain practices.

Nevertheless, the business value of certification should not be treated as automatic. Certification can support credibility, but it does not independently guarantee higher sales, increased profitability, or access to export markets. These outcomes also depend on commercial capabilities, distribution arrangements, product competitiveness, and the recognition of the relevant certification within target markets.

Accordingly, this paper treats Halal certification as a potential business-enabling mechanism rather than a sufficient condition for competitiveness.

5.2 Financial and administrative constraints

Certification may involve direct fees, preparation expenses, documentation, assessments, staff training, and adjustments to production or recordkeeping arrangements. The relative burden of these activities may be greater for businesses with limited financial and administrative resources.

Research on SMEs in the food and beverage industry in northern Johor, Malaysia, identified documentation management and certification costs among the challenges reported by participating entrepreneurs (Yunos et al., 2025). Although those findings cannot be assumed to apply directly to Pakistani SMEs, they demonstrate the relevance of examining both financial and administrative aspects of certification.

For SMEs, a financial assistance program may therefore be insufficient if businesses lack the technical knowledge needed to prepare applications and maintain compliance. Similarly, training may have limited effects if firms cannot afford the practical changes required to meet applicable requirements.

This suggests that financial and administrative interventions should be considered together.

5.3 Technical capacity and food-safety systems

Halal certification requires businesses to understand and implement applicable requirements within their operations. Depending on the product and certification scheme, this may involve ingredient verification, supplier documentation, segregation arrangements, traceability, cleaning procedures, and

internal records.

Research examining food-safety standards among Pakistani SMEs found that some businesses experienced difficulties applying international standards because of cost and language barriers. The study also highlighted the importance of understandable and practically applicable standards for SMEs (Qamar et al., 2024).

Although food-safety certification and Halal certification are not interchangeable, the research provides relevant contextual insight: complex technical requirements may create implementation difficulties for smaller businesses. A Halal certification support program should therefore consider the organizational capacity needed to implement and sustain compliance, while keeping Shariah-related requirements distinct from general food-safety requirements.

5.4 Institutional support and certification procedures

SMEs may require assistance in understanding certification requirements, identifying appropriate certification services, preparing documentation, and responding to assessment observations. Coordination between businesses and relevant institutions may help make the process easier to understand.

Digital tools may provide application guidance, standardized forms, checklists, and reminders for maintaining records or completing renewal-related activities. However, digitalization should not be treated as a complete solution. Businesses with limited digital literacy, internet access, or administrative capacity may need additional assistance.

The proposed approach therefore combines digital guidance with human support rather than replacing personal assistance entirely.

5.5 Halal standards and the Pakistani context

Pakistan's standards framework includes PS:3733-2022 (R), based on OIC/SMIIC 1:2019, concerning general requirements for Halal food, and PS:4992-2022 (R), based on OIC/SMIIC 2:2019, concerning requirements for bodies providing Halal certification (PSQCA, n.d.).

These standards provide a relevant basis for examining how certification requirements are communicated and implemented. Nevertheless, the applicability of particular requirements depends on the business, product, certification scheme, and relevant regulatory arrangements.

For SMEs in Khyber Pakhtunkhwa, future research should investigate how businesses understand the applicable requirements, where they experience difficulties, and what forms of assistance would be practical within their local operating conditions.

5.6 Research gap

The reviewed literature establishes that certification costs, documentation, technical capabilities, and institutional support are relevant issues for SMEs. However, evidence from other countries cannot automatically explain the experiences of food-sector SMEs in Khyber Pakhtunkhwa.

The specific contribution of this paper is to organize these concerns into an integrated, threestage support framework that links certification readiness, continuing compliance, and market development. It also identifies propositions for examining the framework through subsequent field research.

The paper does not claim that no previous study has developed a similar model. Instead, its contribution lies in proposing a locally focused structure that can be refined and assessed using evidence from SMEs and certification stakeholders in the province.

6. Research Methodology

6.1 Research design

The present paper adopts a conceptual research design based on the synthesis of relevant academic literature, published research, and official standards information. Its purpose is to develop an explanatory framework and formulate propositions for future empirical investigation.

The framework is not presented as the result of completed fieldwork. No original survey, interview, or experimental data have been collected for this conceptual paper.

A subsequent empirical phase is proposed to assess the relevance of the framework to Halal food SMEs in Khyber Pakhtunkhwa.

6.2 Proposed study population and geographical scope

The proposed field research will focus on SMEs operating in the Halal food sector in selected districts of Khyber Pakhtunkhwa. Potential participants will include SME owners, managers, or personnel responsible for production and compliance, as well as relevant Halal certification professionals and institutional stakeholders. Peshawar, Mardan, Bannu and Haripur may be considered as possible research locations, subject to the availability of eligible businesses and access to participants. The final geographical scope will be determined before data collection. The study will define its SME eligibility criteria before sampling, using an appropriate and clearly stated definition applicable to the research.

6.3 Proposed sampling and data collection

A mixed-method design is proposed for the empirical phase.

First, a structured questionnaire will be administered to selected SME owners or managers to examine their awareness of certification requirements, perceived costs, documentation capacity, access to technical guidance, certification status, and perceived market opportunities.

Second, semi-structured interviews will be conducted with selected SME representatives and relevant certification stakeholders to explore their experiences, institutional challenges, and views on possible support mechanisms.

A purposive or stratified sampling approach may be considered, depending on the availability of an appropriate sampling frame. The sample size will be established through a justified research design and practical feasibility assessment rather than assumed in advance.

Participation will be voluntary, and appropriate consent and confidentiality procedures will be followed.

6.4 Proposed data analysis

Quantitative data will be analyzed using descriptive statistics to summarize participant characteristics and the frequency or distribution of reported challenges. Where the sample and measurement quality permit, appropriate association tests may be used to explore relationships between certification

statuses, reported barriers, institutional support, and perceived market access.

Qualitative interviews will be analyzed thematically. The analysis will identify recurring themes concerning certification procedures, technical capacity, financial constraints, and proposed support arrangements.

The two forms of evidence will then be compared to identify areas of agreement, differences in stakeholder perspectives, and potential modifications to the conceptual framework.

No statistical results or qualitative themes are claimed at this stage. The analytical techniques ultimately used will depend on the data collected and the suitability of the selected methods.

7. Proposed Halal SME Support Framework

The proposed framework treats certification support as a connected process rather than a single intervention. It contains three stages supported by four complementary mechanisms.

7.1 Stage One: Certification readiness

The first stage concerns preparing SMEs to understand and meet applicable certification requirements.

Potential activities include introductory training, preliminary compliance assessments, ingredient and supplier documentation guidance, and explanations of the applicable certification procedures.

A readiness assessment could help businesses identify gaps before submitting an application. This may reduce avoidable administrative difficulties, although its effectiveness would need to be evaluated empirically.

7.2 Stage Two: Continuing compliance

Obtaining certification may be followed by ongoing responsibilities, depending on the relevant certification scheme. Businesses may need to maintain records, manage changes to ingredients or suppliers, implement required procedures, and respond to follow-up assessments. The second stage therefore emphasizes continuing technical guidance, accessible documentation tools, and periodic capacity-building activities.

Digital checklists and standardized templates could assist businesses in organizing records. These tools would support, rather than replace, the requirements of the applicable certification body.

7.3 Stage Three: Market development

The third stage addresses the distinction between certification and commercial competitiveness. Certified SMEs may still face difficulties in packaging, distribution, product development, marketing, and establishing relationships with buyers. Support programs could therefore connect eligible businesses with relevant trade networks, retailers, institutional buyers, and exportsupport services.

Such support should not promise that certification will automatically lead to increased sales or exports. Its purpose is to help SMEs understand and address additional barriers to commercial participation.

7.4 Four integrated support mechanisms

Financial assistance: Targeted support could help eligible SMEs meet reasonable certificationrelated expenses. Eligibility criteria, transparent procedures, and accountability mechanisms would be needed

to ensure that support reaches businesses facing genuine resource constraints.

Technical advisory services: Shared advisory facilities or scheduled consultation services could help SMEs understand requirements, prepare documentation, and develop practical compliance procedures.

Simplified and digitally supported guidance: Clear application instructions, standardized forms, checklists, and accessible information in appropriate languages could improve understanding. Digital services should be accompanied by assistance for businesses with limited digital capacity.

Institutional coordination and market linkages: Coordination among SMEs, certification bodies, relevant government institutions, and commercial support organizations could improve access to information and reduce fragmentation. Market-linkage activities could help businesses explore opportunities beyond the initial certification process.

The four mechanisms are intended to be complementary. Their actual effectiveness and relative importance must be established through subsequent field research.

8. Research Propositions for Empirical Validation

The proposed framework generates three propositions for future investigation.

Proposition 1: SMEs receiving both financial assistance and technical guidance may demonstrate greater certification readiness than comparable SMEs receiving only one form of support.

This proposition can be examined by comparing reported readiness, application preparedness, and relevant certification progress among businesses with different forms of support.

Proposition 2: Access to continuing technical guidance and practical documentation tools may be positively associated with SMEs' perceived ability to maintain certification requirements.

This proposition can be investigated through measures of recordkeeping capacity, awareness of applicable obligations, access to advice, and reported compliance difficulties.

Proposition 3: Institutional coordination and market-linkage support may strengthen the relationship between Halal certification and SMEs' perceived access to formal buyers.

This proposition requires distinguishing certification status from actual market outcomes. Possible indicators include access to new buyers, participation in formal supply arrangements, and reported export readiness.

These propositions are theoretical expectations, not confirmed findings. Their relationships may differ according to enterprise size, business experience, product category, and market orientation.

9. Discussion and Practical Implications

The proposed framework suggests that Halal certification support should address more than the immediate process of obtaining a certificate. Businesses may need different forms of assistance at different stages, and a uniform support program may not adequately address these differences.

For policymakers, the framework provides a basis for considering targeted financial assistance alongside technical capacity-building. Financial support may address affordability, while technical assistance may help businesses understand and implement requirements. The combination should be

evaluated rather than assumed to be effective.

For Halal certification bodies, the framework highlights the potential value of clear guidance, accessible documentation requirements, transparent communication, and appropriate explanations of assessment and follow-up procedures. These measures should operate within applicable certification requirements and should not compromise the integrity of the certification process.

For SME support institutions, the framework emphasizes practical training, documentation assistance, and coordination with relevant technical experts. Businesses may benefit from guidance that relates certification requirements to their actual production and recordkeeping practices.

For SMEs, the proposed approach encourages a longer-term perspective on certification. Businesses should consider not only the initial application but also the resources and procedures needed to maintain compliance. They should also assess whether certification aligns with their intended markets and broader commercial strategy.

Finally, market development should be treated as a distinct but connected objective. Certification may help establish credibility, but SMEs may require additional support in product quality, packaging, pricing, distribution, and buyer engagement. These factors should be considered when evaluating the broader contribution of certification to business competitiveness.

10. Limitations and Future Research

This paper has several limitations. First, it is conceptual and does not present original empirical data from SMEs or Halal certification stakeholders in Khyber Pakhtunkhwa. Consequently, it cannot establish the prevalence, relative importance, or statistical relationships of certification barriers in the province.

Second, the proposed framework is a structured analytical proposal rather than a validated model. Its usefulness depends on whether its components reflect the actual needs, resources, and institutional conditions of SMEs.

Third, the paper focuses on food-sector SMEs. Its proposed framework may require modification before application to pharmaceuticals, cosmetics, logistics, tourism, or other sectors with different certification requirements.

Future research should therefore collect primary data from SMEs and certification stakeholders in selected districts of Khyber Pakhtunkhwa. The findings should be used to refine the framework, prioritize support interventions, and assess the feasibility of implementing them.

Where appropriate, longitudinal research could subsequently examine whether particular support interventions are associated with improvements in certification readiness, compliance maintenance, buyer access, or export preparedness. Any claims about business performance should be based on suitable evidence rather than inferred from certification status alone.

11. Conclusion

Halal certification offers SMEs a potential means of demonstrating conformity with applicable Halal requirements and strengthening their position in certified markets. However, the ability to obtain certification and benefit from it may depend on financial resources, technical capabilities,

administrative systems, and access to institutional and commercial support.

This conceptual paper proposes a context-specific framework for Halal food SMEs in Khyber Pakhtunkhwa, Pakistan. The framework integrates financial assistance, technical advisory services, simplified and digitally supported guidance, and institutional coordination across three stages: certification readiness, continuing compliance, and market development.

Its principal contribution is to connect the certification process with the capabilities needed to maintain compliance and pursue commercial opportunities. Rather than treating certification as an automatic route to competitiveness, the framework recognizes that businesses may require additional support to translate compliance into meaningful market participation.

The framework provides a foundation for subsequent empirical investigation. Research involving SMEs and Halal certification stakeholders in Khyber Pakhtunkhwa will be necessary to establish which barriers are most significant, which interventions are feasible, and how the proposed approach should be adapted to local conditions. Such evidence can help develop more accessible and commercially relevant support programs while maintaining the integrity of Halal certification.

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(O-36) MAQASID-BASED ISLAMIC SOCIAL FINANCE MODEL FOR HALAL FOOD ACCESS IN ENGLAND AND WALES

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Abstract

Muslim households in the Muslim-minority markets often face monetary, spatial, informational, and administrative barriers when seeking credible halal food, particularly where food insecurity, limited mobility, emergency provision, or weak information reduces practical choice. Existing Islamic social finance literature explains the functions of charitable transfers, benevolent lending, endowments, cooperatives, and social investment, but provides limited guidance on when institutions should intervene, which actor bears responsibility, which response is proportionate, and how outcomes should be governed and reviewed.

This conceptual study develops the Halal Access Social Finance Model for halal food access in England and Wales. Using a structured integrative review and theory-synthesis approach, the study brings together five bodies of knowledge: halal integrity and credence markets, food insecurity and food aid, Islamic social finance, the higher objectives of Islamic law, and nonprofit governance. The model begins with a verified burden record and applies six cumulative decision tests: valid purpose, contextual priority, means-ends fit, coherence and prevention of harm, justice and agency, and realised outcomes and learning.

The model treats financial instruments as possible means rather than automatic solutions and requires institutions to distinguish between financial and non-financial responses, including provider disclosure, procurement reform, public-service correction, advice, referral, partnership, or non-intervention. It further links burden-generating mechanisms to responsible actors, applies non-compensable integrity and governance safeguards, and requires stronger evidence as institutional commitments become more costly, risky, or irreversible. Three contrasting case vignettes illustrate the model's ability to discriminate among inappropriate emergency food provision, chronic household insufficiency combined with travel burdens, and premature investment in community food infrastructure.

The study contributes an auditable and evaluation-ready framework that integrates diagnosis, responsibility attribution, proportional intervention, governance, and outcome-led learning. It argues that neither observed hardship nor the availability of Islamic financial resources is sufficient to justify intervention. Rather, a defensible response requires a credible compliance-related barrier, causal alignment between problem and response, protection against serious harm, and evidence that the intervention improves access, welfare, dignity, and institutional accountability. The model remains conceptual and requires expert review, stakeholder testing, and field validation before wider application.

Keywords: halal food access; Islamic social finance; Maqasid al-Shariah; food insecurity; England and Wales

(O-37) A QUR'ANIC FRAMEWORK FOR SUSTAINABLE HALAL FINANCE: LINKING FINANCIAL TECHNOLOGY, PRODUCTIVE WAQF AND HUMANITARIAN IMPAC

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Abstract

The expansion of the global halal economy raises a fundamental question beyond commercial growth and regulatory compliance: how can financial activity generate sustainable resources for social welfare while reducing dependence on recurring charitable donations? This paper proposes a Qur'anic ethical framework connecting financial technology, productive waqf and humanitarian development.

The study adopts an exploratory, qualitative approach combining conceptual analysis of Qur'anic economic principles with an examination of Islamic finance and waqf governance. Particular attention is given to justice, trusteeship, responsible wealth management, social solidarity and the avoidance of waste. These principles inform the development of a framework for linking ethical commercial activity with long-term humanitarian financing.

Two practice-based illustrations provide the institutional context. Gardens of the Sincere, a Belgian humanitarian organisation operating internationally, illustrates the potential transition from short-term relief towards sustainable development projects. SINCERE, a Belgian ethical financial technology initiative, provides an example of a business model that commits 49 percent of its net profits to humanitarian and social purposes. These cases are used to explore institutional design rather than to claim independently verified financial or social outcomes.

The preliminary analysis identifies three interconnected mechanisms: ethical revenue generation, transparent allocation of financial resources and the development of productive assets capable of supporting recurring social benefits. It also identifies essential governance conditions, including the protection of endowed capital, appropriate Shariah oversight, financial transparency and measurable beneficiary outcomes.

The paper concludes provisionally that allocating commercial profits to charitable purposes does not automatically establish a productive waqf or guarantee sustainable impact. Long-term effectiveness depends on legally and religiously sound institutional structures, appropriate risk management and evidence-based evaluation.

The proposed framework contributes to discussions on sustainable halal economic development by demonstrating how financial innovation and Islamic philanthropic institutions may be integrated into a coherent model for responsible wealth circulation and durable humanitarian financing.

Keywords: Qur'anic economic ethics, Islamic finance, Productive waqf, Financial technology, Humanitarian sustainability

(O-38) WHO RECOGNIZES WHOM? MUTUAL RECOGNITION AND THE LEGAL GOVERNANCE OF CROSS-BORDER HALAL TRADE

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Abstract

The expansion of the global halal economy has turned halal certification into more than a domestic mechanism of religious and consumer assurance. It increasingly operates at the point where national regulatory systems meet international trade. Yet a certificate issued in one jurisdiction does not necessarily acquire regulatory effect in another. The central question is therefore not simply whether a product has been certified as halal, but who has the authority to recognize that certification across borders and under what conditions.

This paper examines mutual recognition as a legal and regulatory mechanism governing the cross-border acceptance of halal certification. It adopts a comparative legal approach focusing on Singapore, Türkiye, and Indonesia, while using the OIC/SMIIC halal quality infrastructure as a normative reference. The analysis distinguishes five functions that are frequently treated as interchangeable: standardization, certification, accreditation, recognition, and market access. It finds that common standards may facilitate regulatory convergence, but they do not by themselves create automatic recognition of certificates issued abroad. Recognition remains an institutional decision through which the destination jurisdiction determines whether a foreign conformity-assessment outcome will have regulatory effect in its market.

The comparison further shows different allocations of institutional authority. Singapore places foreign certification bodies within a formal recognition framework administered by MUIS; Türkiye places particular institutional emphasis on accreditation through HAK and related international cooperation; while Indonesia incorporates recognition of foreign halal certification within a nationally regulated halal assurance system. The paper argues that mutual recognition should therefore be understood not merely as a technical arrangement, but as a legal bridge between conformity assessment and market access. Such an approach can facilitate international halal trade while preserving the regulatory authority of destination jurisdictions.

Keywords: halal certification, mutual recognition, accreditation, halal trade, regulatory governance

1. Introduction

The growth of the global halal economy has transformed halal certification from a primarily domestic assurance mechanism into an increasingly important component of international trade governance. Products may be manufactured, certified, exported, imported, and marketed across several jurisdictions, each of which may apply its own institutional arrangements for determining whether a product can be treated as halal. The existence of a halal certificate in the country of origin therefore does not necessarily mean that the same certificate will have legal or regulatory effect in the destination market. Recent international trade research confirms that recognition of foreign halal certification and accreditation bodies remains a recurring regulatory issue (Johan & Schebesta, 2022; Simatupang & Salim, 2026).

This distinction raises a question that is often obscured by discussions of harmonization: **who recognizes whom?** A halal certificate is normally the outcome of a conformity-assessment process. Yet the legal consequences of that certificate depend on the institutional framework of the jurisdiction in which it is presented. The authority responsible for recognition may be a religious council, a national regulator, an accreditation body, or another institution empowered by domestic law.

The distinction between standardization, certification, accreditation, and recognition is particularly important. OIC/SMIIC 2:2019 establishes requirements for bodies providing halal certification, while OIC/SMIIC 3:2019 establishes requirements for halal accreditation bodies accrediting halal conformity-assessment bodies. SMIIC states that OIC/SMIIC 3:2019 is also appropriate as a requirements document for peer evaluation in mutual-recognition arrangements among halal accreditation bodies (Standards and Metrology Institute for Islamic Countries [SMIIC], 2019a, 2019b). Thus, the halal quality infrastructure itself separates several institutional functions rather than treating them as one process.

This institutional fragmentation is not merely theoretical. International trade-law scholarship has documented foreign halal certification and accreditation recognition as recurring concerns in the WTO's Technical Barriers to Trade (TBT) and Sanitary and Phytosanitary Measures (SPS) committees. Johan and Schebesta (2022) identified recognition-related concerns among the principal trade issues arising from domestic halal measures. More recently, Simatupang and Salim (2026) found that recognition of foreign halal certification and accreditation bodies, together with procedural and administrative requirements, remains among the issues raised in relation to the WTO compatibility of halal measures.

At the same time, the existence of mutual-recognition arrangements does not resolve the underlying institutional question. A mutual-recognition arrangement must still determine which bodies are recognized, which scopes are covered, what conditions apply, and what legal effect follows from recognition. The issue is consequently not whether mutual recognition exists in the abstract, but how legal authority over recognition is allocated.

This distinction also corresponds with the broader logic of international trade law. The WTO Agreement on Technical Barriers to Trade encourages Members to use relevant international standards as a basis for technical regulations and provides for positive consideration of equivalent technical regulations. These provisions facilitate regulatory convergence, but they do not establish a general rule that a conformity-assessment result issued abroad must automatically be accepted (World Trade Organization [WTO], 1994).

Recent scholarship has increasingly examined halal certification from the perspective of international trade and regulatory pluralism. Comparative research has identified differences among national halal certification frameworks as potential challenges for international trade (Zhang et al., 2026), while recent research focused specifically on Indonesia has examined mutual-recognition agreements as instruments for reducing duplicated certification procedures and facilitating cross-border halal trade (Manthovani et al., 2025). These contributions establish the importance of mutual recognition, but leave room for a more focused legal-institutional analysis of the recognition function itself.

Against this background, this paper asks:

To what extent can mutual recognition of halal certification facilitate cross-border trade while preserving national regulatory authority?

Three subsidiary questions guide the analysis:

1. How should standardization, certification, accreditation, and recognition be distinguished in legal and regulatory terms?
2. How do Singapore, Türkiye, and Indonesia allocate institutional authority over the recognition or acceptance of foreign halal certification?
3. Can mutual recognition facilitate market access without transforming recognition into an automatic consequence of certification abroad?

The central argument is that recognition constitutes a distinct legal gateway between conformity assessment and market access. Common standards and accreditation mechanisms can facilitate that gateway, but they do not eliminate the institutional authority of the destination jurisdiction.The contribution of the paper is therefore not to claim that mutual recognition itself is a new concept in halal governance. Rather, it reframes the issue by identifying recognition authority as a distinct object of legal analysis and by examining its position within the broader regulatory sequence connecting standards, certification, accreditation, and market access.

2. Methodology and Comparative Analytical Framework

The paper adopts a comparative legal and regulatory methodology. It examines official regulatory materials and institutional frameworks in Singapore, Türkiye, and Indonesia and places them within the broader normative framework developed by OIC/SMIIC. Primary materials include institutional rules, accreditation procedures, recognition arrangements, official registers, and regulatory statements concerning foreign halal certification.

The comparison is organized around five functions: (1) standardization, (2) certification, (3) accreditation, (4) recognition, and (5) market access. This functional approach avoids assuming that institutions performing one function necessarily exercise authority over the others.

Singapore, Türkiye, and Indonesia were selected because they illustrate different institutional configurations. Singapore provides a clear example of a destination-oriented recognition mechanism for foreign halal certification bodies. Türkiye places particular institutional emphasis on accreditation through the Halal Accreditation Agency (HAK) and the wider cooperation among halal accreditation bodies. Indonesia provides a national halal assurance framework in which foreign certification is incorporated through bilateral recognition arrangements.

The analysis is qualitative and does not attempt to rank the three jurisdictions. Their differences are treated as evidence of alternative ways of allocating regulatory authority. The comparison therefore focuses on institutional functions and legal consequences rather than on the relative performance of the systems.

3. Results

3.1 Singapore: Recognition as the Regulatory Gateway

Singapore provides a particularly clear illustration of recognition as a distinct regulatory function. MUIS states that it does not certify food products manufactured overseas. Instead, imported halal products depend on foreign halal certification bodies (FHCBs) recognized by MUIS (Majlis Ugama Islam Singapura [MUIS], 2026a).

This arrangement creates a direct institutional distinction between certification and recognition. A foreign body may issue a halal certificate in its own jurisdiction, but its certification becomes relevant

to the Singaporean market through MUIS recognition. The current MUIS FHCB framework provides for application, documentary assessment, assessment of personnel and systems, risk assessment, approval, listing, and continuing reporting. The framework therefore treats recognition as an institutional assessment of the foreign certification body rather than as a simple acceptance of any certificate issued abroad (MUIS, 2026a).

This structure demonstrates why recognition should be treated as a separate legal and regulatory stage. Certification takes place in the exporting jurisdiction; recognition determines whether the certifying body is accepted within the regulatory environment of the importing jurisdiction.

Singapore consequently illustrates a recognition-centred configuration in which the destination authority retains an active role in determining the regulatory effect of foreign halal certification. The legal bridge between foreign certification and domestic market access is therefore constituted by an institutional recognition process.

3.2 Türkiye: Accreditation as Institutional Assurance

Türkiye presents a different institutional configuration. HAK describes halal accreditation as the assessment, accreditation, and monitoring of the competence of halal conformity-assessment bodies against applicable regulations, standards, and technical rules (Halal Accreditation Agency [HAK], 2026a).

HAK's accreditation architecture operates with reference to OIC/SMIIC halal standards and related conformity-assessment requirements. Its current register, updated on 14 September 2026, includes accredited halal conformity-assessment bodies operating in Türkiye and other countries and identifies their accreditation scopes (HAK, 2026b).

The Turkish framework therefore places substantial institutional emphasis on the credibility and competence of conformity-assessment bodies. Accreditation functions as an assurance mechanism positioned between certification and broader regulatory acceptance.

This does not mean that accreditation and recognition are identical. Accreditation addresses whether a conformity-assessment body satisfies defined competence requirements. Recognition, by contrast, concerns the regulatory effect attributed to the resulting certification within another jurisdiction or institutional system.

The distinction becomes particularly relevant in the development of the Islamic Forum for Halal Accreditation Bodies (IFHAB). HAK explains that mutual recognition among accreditation bodies can prevent duplicate certifications and accreditations and facilitate the acceptance of accredited halal certification across participating systems (HAK, 2026c). The initiative therefore illustrates

how accreditation systems can provide the institutional infrastructure for mutual recognition without eliminating the distinct legal functions of accreditation and recognition.

The Turkish case thus places particular institutional emphasis on accreditation as a foundation for wider regulatory acceptance, while international cooperation provides mechanisms through which accredited conformity-assessment outcomes may become more portable across jurisdictions.

3.3 Indonesia: Mutual Recognition within a National System

Indonesia illustrates a further configuration in which foreign halal certification is incorporated into a nationally regulated halal assurance system. Recent Indonesian policy developments demonstrate that mutual recognition is being used as an explicit instrument for connecting foreign halal certification bodies with the Indonesian regulatory framework.

The Indonesian Halal Product Assurance Agency (BPJPH) has stated that recognition agreements and mutual-recognition arrangements with foreign halal institutions are intended to facilitate the acceptance of foreign halal certificates while preserving Indonesia's domestic halal requirements (Badan Penyelenggara Jaminan Produk Halal [BPJPH], 2026a). In February 2026, BPJPH expressly clarified that reciprocal cooperation does not remove Indonesia's legal requirement for halal certification and labelling where the law requires them; rather, recognition arrangements simplify the procedure by allowing certificates issued by recognized foreign bodies to be accepted within the Indonesian system (BPJPH, 2026a).

This distinction is important for the present analysis. Mutual recognition does not transform a foreign certificate into an automatically effective instrument independent of Indonesian law. It creates a regulated pathway through which a foreign certification body and its certificates can acquire recognition within the destination system.

The institutional development is continuing. In May 2026, BPJPH reported the conclusion of several international cooperation arrangements, including a Mutual Recognition Agreement with Morocco's national standardization body, while in September 2026 it reported the signing of fifteen additional MRAs with international halal certification bodies (BPJPH, 2026b, 2026c). These developments illustrate that recognition is being constructed through institutional agreements rather than assumed to follow automatically from the existence of a foreign certificate.

Indonesia can consequently be understood as a state-centred configuration in which mutual recognition operates within, rather than outside, the national halal assurance system.

4. Discussion

4.1 From Harmonization to Recognition Authority

The comparison reveals a fundamental distinction between harmonization and recognition.

OIC/SMIIC standards can create a common technical and institutional language. OIC/SMIIC 2:2019 establishes requirements for bodies providing halal certification, while OIC/SMIIC 3:2019 establishes requirements for halal accreditation bodies and is also relevant to peer evaluation for mutual-recognition arrangements (SMIIC, 2019a, 2019b).

Nevertheless, the existence of common standards does not eliminate the institutional decision of the destination jurisdiction.

The distinction can be expressed simply:

Harmonization does not equal recognition.

The WTO TBT Agreement supports this distinction. Article 2.4 addresses the use of relevant international standards as a basis for technical regulations, while Article 2.7 addresses positive consideration of equivalent technical regulations. These provisions encourage regulatory convergence but do not establish a universal rule of automatic recognition of every foreign conformity-assessment outcome (WTO, 1994).

The WTO experience also demonstrates that recognition itself can become a trade concern. Johan and Schebesta (2022) identified recognition of foreign halal certification and accreditation bodies among recurring concerns surrounding halal measures, while Simatupang and Salim (2026) more recently identified recognition, accreditation, procedural requirements, and international standards among the principal issues arising in the WTO-related analysis of halal measures.

The legal problem is therefore not simply the absence of common standards. It may arise from the institutional gap between a standard being shared and a certificate being given regulatory effect.

4.2 Recognition as a Legal Form of Market Access

Recognition should therefore be positioned between conformity assessment and market access.

A simplified regulatory sequence is:

Standardization → Certification → Accreditation / Institutional Evaluation → Recognition → Market Access

Each stage answers a different question.

Standardization asks: What requirements should apply?

Certification asks: Does the product, service, process, or organization comply with those requirements?

Accreditation asks: Is the conformity-assessment body competent to perform the relevant assessment?

Recognition asks: Will the destination jurisdiction give regulatory effect to that conformity-assessment outcome?

Market access asks: Can the product lawfully enter or circulate within the destination market?

This sequence explains why recognition deserves independent legal analysis. It is the point at which a technical or religious conformity-assessment outcome becomes capable of producing consequences within another regulatory order.

The Singapore model makes this particularly visible. MUIS does not simply rely on the existence of foreign certification; it maintains a recognition framework for the bodies responsible for that certification (MUIS, 2026a). Recognition therefore operates as a regulatory gateway between a foreign conformity-assessment outcome and its domestic consequences.

The Indonesian framework reaches a related result through a different institutional path. BPJPH describes mutual recognition as a mechanism for simplifying procedures while maintaining the legal requirements applicable to products entering the Indonesian market (BPJPH, 2026a). The institutional form differs, but the legal function is comparable: recognition determines when an external conformity-assessment outcome becomes usable within the destination regulatory order.

4.3 Mutual Recognition and Regulatory Autonomy

Mutual recognition can reduce duplication and facilitate trade, but it does not necessarily require states to surrender regulatory authority.

The institutional logic surrounding OIC/SMIIC 3:2019 and IFHAB is significant in this regard. Mutual-recognition arrangements can allow accreditation bodies to rely on evaluations performed within a common framework rather than requiring repeated accreditation for the same scope (HAK, 2026c; SMIIC, 2019b).

The legal effect is therefore better understood as **coordinated recognition rather than automatic equivalence**.

A mutual-recognition arrangement can specify:

- which institutions are recognized;

- which scopes of certification are covered;
- what standards and procedures apply;
- how competence is evaluated;
- what monitoring and reassessment mechanisms exist; and
- under what circumstances recognition may be suspended or withdrawn.

This allows regulatory cooperation without eliminating national regulatory discretion.

The phrase “mutual recognition” should consequently not be interpreted as meaning that one jurisdiction simply accepts everything certified by another. Rather, it describes an institutional commitment to give defined regulatory effect to conformity-assessment outcomes produced within an agreed framework.

The distinction is particularly important because recognition can operate at different institutional levels. A state may recognize a foreign certification body directly, as illustrated by the Singapore framework; accreditation bodies may recognize one another’s accredited conformity-assessment bodies, as envisaged by the IFHAB framework; or a national system may incorporate foreign certification through bilateral recognition arrangements, as illustrated by Indonesia. These mechanisms share a trade-facilitation objective but allocate legal authority differently.

4.4 Recognition Without Institutional Uniformity

The comparison also suggests that mutual recognition does not require the disappearance of institutional diversity.

Singapore retains a statutory religious authority at the centre of its recognition framework. Türkiye relies on a specialised accreditation institution and international cooperation among accreditation bodies. Indonesia uses a national halal assurance framework in which recognition agreements connect foreign certification bodies to the domestic regulatory system. These arrangements differ in institutional form while pursuing a related regulatory function: creating a controlled pathway through which foreign conformity-assessment outcomes can acquire legal relevance.

This is significant for the future development of halal trade. Complete institutional uniformity would require substantial convergence of domestic legal systems, religious authorities, accreditation arrangements and administrative procedures. Mutual recognition offers a less demanding alternative: different systems may remain legally distinct while establishing agreed conditions for accepting defined external outcomes.

Recent Indonesian practice illustrates this approach particularly clearly. BPJPH has continued to conclude recognition agreements with foreign halal bodies while simultaneously maintaining the domestic legal requirement that products falling within the mandatory halal regime comply with Indonesian rules (BPJPH, 2026a, 2026c). Recognition therefore operates as an instrument of regulatory coordination rather than regulatory surrender.

The broader implication is that the legal architecture of cross-border halal trade may develop through **interoperability rather than uniformity**. Common standards can provide a shared reference point; accreditation can increase confidence in the competence of conformity-assessment bodies; and mutual recognition can connect those systems to market access. Yet the destination jurisdiction retains the authority to define the conditions under which external assurances receive legal effect.

5. Conclusion

The question “Who recognizes whom?” reveals an important but sometimes overlooked dimension of cross-border halal trade.

Halal certification is not necessarily the final legal step in the movement of a product across borders. A certificate may demonstrate conformity in the jurisdiction where it was issued, while its regulatory effect in another jurisdiction remains dependent upon the institutional framework of that destination.

The comparison of Singapore, Türkiye, and Indonesia demonstrates three different configurations. Singapore places foreign certification bodies within a formal recognition system administered by MUIS. Türkiye places particular institutional emphasis on accreditation through HAK and cooperation among halal accreditation bodies. Indonesia incorporates foreign certification and mutual-recognition arrangements within a broader national halal assurance framework.

These differences do not necessarily represent competing models in which one must replace the others. Instead, they demonstrate that halal governance distributes authority among several institutional functions.

The principal finding is that recognition should be understood as a distinct legal gateway between conformity assessment and market access. Standardization can facilitate convergence; certification can establish conformity; accreditation can provide assurance concerning institutional competence; but recognition determines whether a foreign conformity-assessment outcome will receive regulatory effect in the destination market.

The contribution of this paper lies in treating recognition authority as an independent object of legal analysis rather than as an automatic consequence of harmonized standards or accreditation. Mutual recognition can consequently serve as a mechanism for facilitating cross-border halal trade while preserving national regulatory authority. Its effectiveness depends not simply on the existence of common standards, but on the legal architecture governing who is authorized to recognize, what is recognized, under which conditions, and with what consequences for market access.

The future development of the global halal economy will therefore depend not only on producing common standards, but also on constructing credible institutional bridges between different regulatory systems. In that context, the legal significance of mutual recognition lies precisely in its ability to connect international regulatory cooperation with domestic regulatory autonomy.

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(O-39) LEGAL AND SHARIAH ANALYSIS OF HALAL FOOD PRODUCTS IN AFRICA AND ASIA.

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Abstract

This study seeks to explore the concept of Shari'ah to analyze the stand of the International Legal Frameworks governing the fresh fruits, vegetables, grains, seafood, livestock-meat and processed foods. Despite the fact that the viability of the application of Halal food products is facing some challenges through the international legal frameworks and international markets, the benefits got from the products outweigh the challenges and many countries welcomed the products. However, there is need to extend the awareness to Africa and show them the hygienic products of Halal foods to the human health. there is need to consult the leading countries in Halal food practices, standards and consumption such as Asian country, the United Arab Emirates and have recorded a huge success and a number of achievements. For this study to be current, the researcher has employed the qualitative research method. This involves a semi-structured interview questions and documentary review. In the end, the study identifies some legal challenges faced by the products in Africa. In order to solve the problems, there is need to reform and reconstruct the framework of the products. The paper argues that the laws to be guiding the implementation of the products should be within the exclusive control of Shari'ah. Also, the consultation of the Asia countries laws will be helpful.

Keywords: Shariah, International Law, Halal food products, international markets, and consumer and consumption.

1.1 Introduction

The universal demand for halal food is expanding speedily across various economies. In Africa and Asia, governments and religious authorities face the complex task of aligning civil legal systems with Shariah ethics (Ambali & Bakar, 2014).

This article examines how nations in these two regions regulate halal production, enforce certification standards, and protect consumers. It highlights the legal challenges of cross-border trade and explores how different jurisdictions bridge the gap between religious compliance and statutory law (Mehboob, 2017)

The researcher examines the legal concepts of the halal products in four countries in both Asian and African countries. This study will attempt to investigate and identify the differences and similarities between the two legal frameworks and their *modus operandi* in the two continents. It is pertinent to analyze how the consumers are being protected in the terms and conditions stipulate in the halal products' regulations. Furthermore, it is a material to examine the cross-boarded halal businesses, in order to determine the extent and their level of compliance with Islamic law. Also, the researcher deems it necessary to examine and find out the benefit to be derived by the society through halal

products under the objectives of *Shariah*. Meanwhile, the research will analyse the legal challenges that are facing in African countries in the course of applying halal products. Moreover, based on the fact that Asian is much older than African in term of halal products regulations, and enjoys more favorable legal framework, the outcome of this research analysis is expected to provide some legal experiences for the successful operation of halal products in African (Zakaria, 2008).

1.2 Regulatory and Statutory Frameworks of Halal Products in Asian Countries

The Asian countries outline halal food, meat standards, and certification through specific national legislation and regulatory sections. The researcher examines four countries from the jurisdiction by way of elucidating their legal and institutional frameworks governing the operation of halal products. They are Malaisia, Indonesia, Singapore and Thailand (Mehboob, 2017).

1.2.1 Malaysia

According to Section 28 of the Trade Descriptions Act 2011 (Act 730), It empowers the Minister to make orders regarding the definition, marking, and certification of halal descriptions. Trade Descriptions (Definition of Halal) Order 2011 (Paragraph 3) defines halal food as complying with Hukum Syarak (Islamic law), free from non-halal/impure (najis) elements, non-hazardous to health, and physically segregated from non-halal items during preparation, processing, or storage (Zakaria, 2008). Furthermore, Trade Descriptions (Certification and Marking of Halal) Order 2011 mandates that the Department of Islamic Development Malaysia (JAKIM) or State Islamic Religious Councils are the sole competent authorities to issue halal certifications and logos to either an individual organization or company engaging in halal products. Moreover, the Food Regulations 1985 (Regulation 11) made some requires specific labeling statements on packaged foods containing beef, pork derivatives, butter, or alcohol (Ambali & Bakar, 2014).

1.2.2 Indonesia

The Law of the Republic of Indonesia No. 33 Year 2014 concerning Halal Product Assurance (HPA Law) and its subsequent amendments governing legislation of halal food and products, and certification body. The Halal Product Assurance Organizing Agency (BPJPH - *Badan Penyelenggara Jaminan Produk Halal*) manages certification, working in coordination with the Indonesian Ulema Council (MUI) which handles religious fatwas and auditor standards (Zakaria, 2008).

In the Indonesia, the Law No. 33 of 2014 concerning Halal Product Assurance (UU JPH)

Article 4 mandates that all products entering, circulating, and traded within the territory of Indonesia must be certified Halal. However, Article 6 of the Law outlines the authority of the Halal Product Assurance Agency under the Ministry of Religious Affairs to formulate policies, issue/revoke halal certificates, and establish standards halal products in the country. Meanwhile, Chapters V & VI on the Articles on Materials and Halal Processes govern the sourcing of halal ingredients (animal, plant, chemical, or biological) and mandatory halal production processes including slaughtering, processing, storage, packaging, and distribution of halal food and products.

In the Trade Regulations arena, **t**he HPA Law mandates that all imported, distributed, or traded products and related services (food, beverages, cosmetics, medicines, and chemical/biological products) in Indonesia must be halal-certified (Zakaria, 2008).

1.2.3 Singapore

The country enacted Administration of Muslim Law Act (AMLA) to see the smooth running of the products. Section 88A empowers the Islamic Religious Council of Singapore (MUIS) to issue halal certificates, regulate halal-eating establishments, and monitor the safety and compliance of halal food preparation, storage, and retail (Khan, *at al*, 2020).

1.2.4 Thailand

The National halal standards and institutional frameworks administered through Islamic and technical boards is the governing legislation as halal products is concerned. While the certification body is the Central Islamic Council of Thailand (CICOT) is the official body overseeing halal certification, supported technically by the Halal Standards Institute of Thailand (HSIT). Furthermore, the Trade Regulations (CICOT) regulates business registrations, audits production guidelines, and ensures compliance for both domestic consumption and international trade (Ambali & Bakar, 2014). All the above-mentioned Asians laws made the details on a specific country**,** meat slaughter (dhabiha) rules**,** or import/export documentation**,** halal certification bodies and trade regulations across Asian countries are governed by specific national legislation and designated government or Islamic authorities (Mehboob, 2017)

1.3.1 Regulatory Models and Governing Sections in some African Countries

Most African countries do not manage halal food and meat through a single dedicated statutory "Halal Law" with uniform section numbers. Instead, halal standards are typically integrated into national food safety, public health, and consumer protection acts, or governed through national standards bodies (such as the Uganda National Bureau of Standards [US 909: General standard for halal food] or similar bodies in Kenya, South Africa, and North African nations like Morocco and Egypt) working alongside recognized Islamic councils (such as the Uganda Muslim Supreme Council or South Africa's SANHA/NIHT). The fundamental frameworks and general standards across Africa, rather than standalone parliamentary acts detailing halal sub-sections, legal compliance relies on cross-referencing general food laws with adopted standards (often aligned with the Codex Alimentarius guidelines for halal food). Section 2 & 3 of Halal Standards / Food and Drugs Acts outlines that halal food must be free from prohibited (*haram*) components like pork, blood, carrion, and alcohol. Restricts permissible land animals to cattle, sheep, goats, camels, and poultry (Khan, *at al*, 2020). The Act did not silent on requirement of slaughtering animals (Dhabihah / Zabiha). It mandates that the animal be alive and healthy at the time of slaughter. The requirement is that the slaughter to be performed by a sane adult Muslim who invokes the name of Allah (*Bismillah*). He should specify a swift, deep cut to the throat severing the trachea, esophagus, and main blood vessels to ensure complete blood drainage (Mehboob, 2017).

Hygiene, Segregation, and Traceability (Linked to Public Health & Food Safety Acts) Requires physical separation, dedicated processing lines, or validated cleaning protocols to prevent cross-contamination between halal and non-halal (or haram) products during storage, transport, and retail handling. The requires clear labeling and certification documentation to prevent fraudulent halal claims in the marketplace (Ambali & Bakar, 2014).

Halal certification bodies and trade regulations across African countries are governed primarily through a hybrid of national standardization bureaus**,** religious Supreme Councils**,** and

regional/international frameworks like the Standards and Metrology Institute for the Islamic Countries (OIC/SMIIC) rather than isolated single statutory codes.

1.3.2 East Africa: Uganda

The Uganda National Bureau of Standards (UNBS) and the Uganda Muslim Supreme Council (UMSC)**,** working alongside on the Uganda Halal Bureau (UHB)**.** The guidelines and operational standards are aligned with national quality enforcement laws and OIC/SMIIC norms. Meanwhile, Certificate of Incorporation, valid trade licenses, complete ingredient/formula disclosures, supplier halal certificates, and facility process workflows. The halal products should be **c**ompliance with audit criteria. The **c**ompliance should be yearly renewable certification cycles requiring physical facility inspections, Shariah-compliance reviews of slaughter/processing, and designated Muslim auditors (mirroring ISO/IEC 17065 and OIC/SMIIC 2**).** Uganda is actively building an institutional halal certification framework (with technical support from international partners like Malaysia to unlock high-value export pathways into North Africa, the Middle East, and broader Asian markets.

1.3.3 South Africa

The governing framework predominantly through private, accredited Islamic bodies and religious authorities rather than a single federal ministry. The South African National Halaal Authority (SANHA) and the Muslim Judicial Council Halaal Trust (MJCHT) are the major certifying bodies of halal products while the **r**egulatory structure is operating on voluntary, industry-accepted standards that integrate general food safety management (GMP/HACCP) with strict Islamic dietary verification (prohibiting pork, alcohol, improper slaughter, and cross-contamination) (Zakaria, 2008).

1.3.4 West Africa: Nigeria

The Nigerian overseen at the national level for food safety and consumer protection by the National Agency for Food and Drug Administration and Control (NAFDAC)**,** intersecting with Islamic affairs and regional standards. The country is aligning with broader African Continental Free Trade Area (AfCFTA) goals, though formal statutory halal tourism and product laws remain in developmental phases relative to multi-sectoral mandates through the trade integration.

1.3.5 North Africa: Morocco

Morocco’s legal and institutional framework for Halal products is built around national standards, public regulatory authorities, and religious oversight bodies designed to guarantee compliance with Islamic law (Sharia) while boosting domestic consumer safety and international trade. The Legislative and Legal Foundation of halal products in Morocco can be found in Law No. 12-06: Governs standardization, certification, and accreditation in Morocco, providing the legal basis for official labels and conformity assessment. However, Moroccan Standards (Normes Marocaines - NM) NM 08.0.800: Defines the core requirements for Halal food products (covering production, handling, storage, and distribution). NM 08.0.802 also outlines standards related to Halal practices and associated sectors. Alignment with International Standards: Moroccan Halal standards are heavily benchmarked against the standards of the Standards and Metrology Institute for Islamic Countries (SMIIC) (such as OIC/SMIIC 1) and reference international benchmarks like Malaysia's MS1500.

IMANOR (Institut Marocain de Normalisation) and certification body operating under Law 12-06. IMANOR manages the official Morocco Halal Label, conducts facility audits, and oversees the

protocol for recognizing foreign Halal Certification Bodies (HCBs). Higher Council of Ulemas (*Conseil Supérieur des Oulémas*): Morocco's supreme religious authority set outline for the halal products to compliance with Sharia. They partner with IMANOR to provide religious oversight, appoint Islamic affairs experts to audit teams, and validate the Sharia compliance of Halal processes (Zakaria, 2008).

ONSSA (Office National de Sécurité Sanitaire des Produits Alimentaires): The national food safety watchdog. ONSSA works alongside IMANOR to enforce mandatory Halal inspections and documentation (such as Halal slaughter certificates) for imported animal and food products.

SEMAC (Service Marocain d'Accreditation) this is operating under the Ministry of Industry and Trade, SEMAC is the sole authorized body responsible for accreditation in Morocco, including the accreditation of bodies certifying Halal conformity. Certification and Compliance Mechanism: The Morocco Halal Label: Assigned by IMANOR to food, and selectively cosmetics and tourism operations, following a rigorous two-stage on-stage audit (conducted jointly by food safety auditors and Islamic affairs specialists) and optional lab analyses (Ambali & Bakar, 2014).

In term of Validity and Surveillance, the Certificates issued under the national system are typically valid for one year, subject to annual surveillance audits and a full recertification cycle every three years (Mehboob, 2017)

In relationship with Foreign Certification Recognition: IMANOR maintains a formal recognition protocol for international Halal certification bodies, allowing approved foreign certifiers to clear Halal-designated imports into the Moroccan market. The specific documentation required to apply for the Morocco Halal Label Import/export rules for Halal meat and food additives Standards applied to Halal cosmetics or tourism in Morocco (Khan, *at al*, 2020).

OIC / SMIIC Standards Governing Halal Bodies & Trade (Pan-African OIC Members)

The active member states of the OIC are 57, while 27 are from African member states of the Organization of Islamic Cooperation (OIC), meanwhile 22 participate directly in the Standards and Metrology Institute for the Islamic Countries (SMIIC) to harmonize cross-border halal trade.

OIC/SMIIC 1 (General Requirements for Halal Food). The requirement of halal food outlines rules for food production, processing, transport, hygiene, and traceability. It details permissible vs. non-permissible (Najis/Haram) ingredients and specific slaughter rules (reciting Tasmiyah, sharp tool usage, complete blood drainage).

OIC/SMIIC 2 (Conformity Assessment – Requirements for Bodies Providing Halal Certification): Specifies the structural, competence, and impartiality requirements for halal certification bodies (modeled after ISO/IEC 17065), ensuring international and regional mutual recognition.

OIC/SMIIC 3 (Requirements for Halal Accreditation Bodies) Governs national bodies that accredit local halal certifiers. Where the OIC/SMIIC 35 (General Requirements for Halal Testing Laboratories): Outlines laboratory protocols, requirement of qualified Muslim personnel, and zero-tolerance for cross-contamination with non-halal/Najis agents during testing.

In deeded the East Africa (Kenya, Uganda, and Nigeria): Formal statutory regulation remains limited, with oversight largely driven by private or regional religious councils rather than unified national

laws. However, institutional shifts are underway: Uganda is actively building a domestic Halal certification ecosystem (with technical assistance from international partners like Malaysia) to unlock export pathways into Middle Eastern and North African markets. Broad administrative bases exist under frameworks like the Uganda Tourism Act and Nigerian statutory acts, though dedicated statutory Halal food and trade laws are still evolving. Africa's Halal landscape is vast and economically significant anchored by a rapidly expanding Muslim demographic and multi-trillion-dollar global market projections, but remains structurally fragmented compared to Asia (Zakaria, 2008).

1.3.6 Regional Harmonization Efforts

African Organisation for Standardisation (ARSO): ARSO established technical committees to harmonize halal standards, build assessment capacity, and address non-tariff trade barriers across African nations to facilitate intra-African and export trade (particularly to Middle Eastern/GCC markets under standards like GSO 2055-1**).** The halal products particularly to industry sector such as meat export, cosmetics, or pharmaceuticals (Khan, *at al*, 2020).

In order to protect halal products under the Islamic law in the two jurisdictions, it should be fashioned according to the principles of *Shariah* in order to enjoy the utmost benefits and drive away Haram products, gambling (*maisir*) and all forms of dubious dealings and uncertainties (*gharar*) (Adam, 2014). Moreover, based on the fact that Asian countries have separating enactments for halal products. The enjoys a more efficient legal framework, the outcome of this research is expected to provide some legal examples for the successful operation of halal products in African and other associated transactions therein (Mehboob, 2017)

2.1 Shariah Foundations of Halal Food

Under Islamic law, halal refers to anything permitted, lawful, or wholesome, while haram designates strictly forbidden elements. The primary legal sources are the Quran and the *Sunnah* of Prophet Muhammad; however, they stablish strict boundaries for nutritional consumption of Halal (Muhammad & Noormazlinah, 2023).

Prohibited Ingredients (Haram)

The Pigs (pork and its derivatives), carrion (dead animals), flowing or coagulated blood, intoxicants (alcohol and mind-altering drugs), and carnivorous animals or birds of prey (Khan, *at al*, 2020).

Slaughter Requirements (*Zabiha*): Permitted livestock must be alive at the time of slaughter, slaughtered by a sane Muslim (or People of the Book under specific classical views, though modern standards increasingly require explicit Muslim slaughterers), and executed via a swift, single-knife stroke severing the trachea, esophagus, and major neck vessels while invoking the name of Allah (*Bismillah*).

Supply Chain Integrity (*Tayyib*): Halal status extends beyond raw ingredients to cover entire production lines. Facilities must prevent cross-contamination with *najis* (unclean) items during processing, storage, packaging, and transport (Ambali & Bakar, 2014). Asian nations particularly in Southeast and South Asia—feature some of the world's most mature, state-backed Halal regulatory ecosystems (Zakaria, 2008).

3. 1 Shariah Principles of Halal Food

In Islamic jurisprudence (*Fiqh*), the general rule for food and non-ritual matters is permissibility (*al-ibahah*) meaning everything is lawful unless explicitly forbidden by authentic and clear texts from the Qur'an or the Sunnah of Prophet Muhammad. The animals prohibited for consumption (haram) or restricted under Sharia are classified based on direct texts from the Quran and supplementary explanations from the Hadith (traditions of Prophet Muhammad). The foundational principle in Quranic dietary law is that Allah permits all wholesome and pure things (tayyibat) and prohibits harmful and impure things (khaba'ith), as stated in Surah Al-A'raf (7:157)**:** "He makes lawful for them the good things and prohibits for them the evil things."

3.2 The Explicitly Prohibited Categories of Animals in the Quran.

The Quran directly forbids specific categories of animals and substances. However, the pig (Swine) strictly forbidden as impure according to Surah Al-Baqarah (2:173), Surah Al-Ma'idah (5:3), Surah Al-An'am (6:145), and Surah An-Nahl (16:115), while carrion (dead animals) animals that die of natural causes, disease, or improper slaughter (al-maitah), with exceptions detailed for properly slaughtered game or livestock. Moreso, the spilled blood that flowing blood drained during slaughter (ad-dam) is unlawful as well as animals dedicated to other than Allah sacrifices or offerings made in the name of deities other than God (Ambali & Bakar, 2014).

3.3. Prohibitions Detailed in the Sunnah of Prophet Muhammad

Building on the Quranic principle of prohibiting harmful things (khaba'ith), The holy Prophet Muhammad specified additional categories that carnivorous land animals with fangs are prohibited such as lions, tigers, wolves and dogs; based on authentic Hadith forbidding wild beasts with canine teeth (Hadith Sahih Muslim, 1934). The Birds of Prey with Talons prohibited, such as eagles, falcons, and hawks. In deed the domesticated donkeys are also prohibited during the campaign of Khaybar. The pests and Insects that are termed general crawling pests and vermin like rats and scorpions, excluding specific exceptions like locusts are forbidden (Khan, 1979).

4.1 Challenges Facing by the Halal Products

The global halal industry faces several major challenges that span certification, supply chains, and market integration:

4.2 Scientific Verification and Supply Chain Challenges

The modern food science relies heavily on complex additives, gelatins, enzymes, and genetically modified organisms (GMOs), Shariah compliance requires advanced analytical verification, the Analytical Techniques Authorities employ protein- and DNA based testing, such as Enzyme-Linked Immunosorbent Assay (ELISA), liquid chromatography-mass spectrometry (LC-MS) for porcine gelatin, real-time Polymerase Chain Reaction (PCR), and gas chromatography for alcohol residues to detect hidden haram adulteration. Additionally, the Scientific Authentication and Regulatory authorities and laboratory’s deploy advanced testing tools to detect adulteration, including ELISA, chromatography, LC-MS, and PCR-based DNA testing (Real-Time PCR and PCR-RFLP) targeting porcine genes (Khan, *at al*, 2020).

Other challenges are the Harmonization Deficit: A central legal challenge in both Africa and Asia is

the lack of a unified global Halal standard. Discrepancies in acceptable stunning methods (e.g., reversible vs. irreversible electrical stunning), permissible chemical additives, and certification mutual recognition create compliance friction and compliance costs in cross-border trade (Khan, *at al*, 2020).

4.3 Doctrines of Transformation and Assimilation

Istihalah (Chemical Transformation), when a forbidden or impure substance undergoes a complete chemical change into a new compound with fundamentally different properties (such as pig bones converting into gelatin), jurists in many schools rule the resulting substance pure and permissible (Mehboob, 2017)

4.4 Istihlak (Dilution/Assimilation)

The minute or negligible presence of an impermissible additive absorbed or diluted into a dominant lawful medium where its characteristics completely vanish (Muhammad & Noormazlinah, 2023).

4.5 Lack of a Unified Global Standard

When the discrepancies persist between different national standards and ulema bodies regarding stunning methods (e.g., reversible vs. irreversible electrical stunning), acceptable gelatin sources, and the mutual recognition of foreign certifiers. There is no single, universal halal standard or governing body. Dozens of different certification boards and labels operate globally, leading to confusion, conflicting rules, and varied reliability among countries and markets.

4.6 Traceability Costs for SMEs

Small-and-medium enterprises often struggle with the cost of dedicated supply chains, lab testing (*PCR/ELISA*), and multi-jurisdictional audits (Muhammad & Noormazlinah, 2023).

4.7 Supply Chain and Production Requirements: Halal integrity is not restricted to the final plate; it spans a strict farm-to-fork model:

4.8 Slaughter Protocols (*Dhabihah*): The animal must belong to a permitted species, be alive and healthy at the time of slaughter, and be dispatched by a sane Muslim via a swift, single stroke to the throat cutting the trachea, esophagus, and jugular veins while invoking the name of Allah (*Bismillah Allahu Akbar*).

4.9 Segregation & Cross-Contamination Prevention: Facilities must maintain physical separation or dedicated lines to prevent contact between halal items and haram items (such as pork products or non-halal cleaning agents) during processing, packaging, storage, and transport (Muhammad & Noormazlinah, 2023).

Processed Ingredients: Complex modern additives, such as gelatin, emulsifiers, enzymes, and flavorings require deep molecular or documentation tracing to verify they do not originate from porcine sources or non-halal microbial cultures. The processed items can accidentally contain haram (forbidden) elements, such as animal-derived gelatin, alcohol, or non-halal enzymes, in products like candies, baked goods, and even pharmaceuticals (Ambali & Bakar, 2014).

5. Findings

There is no single global halal standard. over 130 different halal standards and certification bodies

operate worldwide, leading to regulatory fragmentation, compliance barriers, and varying interpretations of Shariah requirements between regions.

In the Asia countries like Malaysia (via MS-1500) and Indonesia have established centralized certification and legal mandates. However, centralized or mandatory certification can trigger political, cultural, and economic friction, such as concerns over bureaucratic complexity, high costs, and the marginalization of small businesses or non-Muslim minority producers.

The Studies note deficiencies in legal recognition, standardized certification procedures in Africa particularly in Uganda, South Africa and Nigeria, and interagency collaboration. While countries like South Africa established early bodies (1975), much of Africa faces hurdles in aligning halal regulations with broader continental frameworks (like Agenda 2063) and integrating Islamic commercial law into food and tourism sectors.

Halal compliance requires avoiding prohibited items (such as pork, blood, carrion, alcohol, and carnivorous animals) and ensuring proper *zabiha* (Islamic slaughter methods), alongside complete separation from non-halal items across the entire supply chain (farm-to-fork).

The researcher emphasizes advanced authentication techniques, such as real-time PCR, liquid chromatography-mass spectrometry (LC-MS), and blockchain technology to improve traceability, reduce fraud, and build consumer trust

6. Recommendation for future researchers

The Regulatory Harmonization and Standardization authorities shall investigate how differing national statutory laws and Shariah interpretations create fragmentation or trade barriers between Southeast Asian hubs (such as Malaysia and Indonesia) and emerging African markets (such as Uganda, Nigeria, and South Africa).

The Institutional and Certification Frameworks authorities should compare the efficacy, legal backing, and interagency collaboration of state-led certification bodies versus independent trusts (like South Africa's MJC Halal Trust). Examine how modern food processing, biotechnology, protein assays (ELISA, PCR), and traceability technologies enforce both religious law and general food safety standards (*thayyiban*) from farm to fork.

Analyze the socio-economic drivers behind non-Muslim consumers choosing halal-certified products based on perceived hygiene, ethics, and quality standards in diverse regional markets.

Evaluate how national legislation—such as Uganda’s Tourism Act or Nigeria’s NTDA Act—interacts with or omits formal recognition of Islamic commercial jurisprudence (*fiqh al-muʿāmalāt*) and dietary standards.

7. Conclusion

The paper reveals that governing halal trade is a complex intersection of divine law, state regulation, economic strategy, and global commerce. The dual foundation (Sharia vs. Statutory Law): Halal compliance is rooted fundamentally in Quranic directives and Hadith (defining *halal* and *haram*), but its practical realization depends heavily on state statutory frameworks such as Indonesia’s Law No. 33 of 2014 or Malaysia's JAKIM standards. Sharia provides the ethical and theological baseline, while

national statutes turn those rules into enforceable consumer protection laws.

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(O-40) DESIGNING SHARIAH-COMPLIANT CONTINGENT LIQUIDITY FACILITIES FOR CLIMATE-RESILIENT MICROFINANCE

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Abstract

Climate-related disasters can severely disrupt the livelihoods of smallholder farmers and micro-entrepreneurs. They can also weaken microfinance institutions when borrowers face widespread difficulties in meeting their financing obligations. International development institutions and climate-finance initiatives increasingly provide concessional funding to support countries and financial institutions after major disasters. In many cases, these funds are channelled through central banks and subsequently distributed through microfinance institutions. However, the underlying funding arrangements may remain interest-based. This issue is particularly relevant in Muslim-majority countries. Some farmers and other potential beneficiaries may be unwilling to take conventional interest-based loans. Islamic microfinance institutions may also prefer to receive and deploy disaster funding through Shariah-compliant arrangements. As a result, an institution may have access to international disaster funding but lack an appropriate Islamic structure through which the funds can be channelled to affected communities. This paper proposes a Shariah-compliant Contingent Liquidity Facility through which a central bank can provide subsidised disaster-related funding to Islamic microfinance institutions without relying on an interest-based wholesale facility. The proposed model creates a dedicated disaster-finance pool within the Islamic microfinance institution. The central bank provides capital to this pool through a Mudarabah arrangement. The microfinance institution manages the funds and the parties share profits according to an agreed ratio. A Musharakah-based structure is also examined as an alternative where the nature of the funding and risk-sharing requirements support joint capital participation. The microfinance institution then deploys the pool to eligible beneficiaries affected by a qualifying disaster and manages the resulting financing exposure. Predefined disaster indicators can be used to activate the facility and accelerate the flow of funds. The study develops a conceptual framework linking international development funding, central banks, Islamic microfinance institutions and affected communities. It examines the movement of funds, risk allocation, profit-sharing and repayment flows within the proposed structure. The paper demonstrates how existing disaster-financing channels could be adapted to Islamic finance while preserving the developmental purpose of concessional funding and expanding access to Shariah-compliant disaster finance in climate-vulnerable communities.

Keywords: Islamic Microfinance, Climate Finance, Contingent Liquidity, Mudarabah, Disaster Risk Finance

(O-41) WHO GOVERNS THE HALAL ECONOMY? RETHINKING THE LEGAL AND REGULATORY ARCHITECTURE OF A GLOBAL HALAL MARKET

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Abstract

The global halal economy has moved beyond a primarily religious and consumer-oriented field and has become an increasingly complex domain of legal and regulatory governance. As halal products circulate through international supply chains, the question is no longer limited to whether a product complies with Islamic requirements. It also concerns which institutions define those requirements, who is authorised to certify compliance, how certification bodies are assessed, and under what conditions a halal certificate acquires regulatory significance in a foreign market. This paper examines these questions through a comparative legal analysis of Singapore, Türkiye and Qatar.

The study adopts a comparative legal and institutional approach, examining the allocation of authority among religious institutions, state authorities, standards organisations, accreditation bodies and halal conformity assessment bodies. The comparison focuses on four dimensions: the legal basis of halal governance, institutional responsibility for certification and assurance, the treatment of foreign halal certification bodies, and the relationship between halal governance and cross-border market access. The three jurisdictions are examined as distinct institutional configurations rather than as models to be ranked.

The comparison demonstrates that the halal economy is not governed through a uniform institutional architecture. Singapore places MUIS, a statutory Islamic institution, at the centre of domestic halal certification and the recognition of foreign halal certification bodies. Türkiye has developed a dedicated accreditation architecture through the Halal Accreditation Agency (HAK), linking halal conformity assessment to accreditation and OIC/SMIIC standards. Qatar incorporates halal certification into a state-administered food-control framework through the approval and listing of Islamic and third-party bodies responsible for issuing halal certificates for relevant imported products.

The paper argues that the regulatory architecture of the global halal market is best understood as a multi-layered system in which religious authority, public regulation, technical standards, accreditation, certification and market access interact without necessarily converging into a single institutional model. The central legal issue is therefore not simply who certifies halal, but who has the authority to give halal status regulatory and market significance across institutional and national boundaries.

Keywords: halal economy; halal governance; halal certification; accreditation; market access

1. Introduction

The global halal economy has undergone a significant institutional transformation. What was once treated primarily as a matter of religious observance and consumer choice has increasingly become

connected with public regulation, conformity assessment, accreditation, food control, international standards and cross-border trade. The expansion of halal markets has therefore created a regulatory environment in which the legal significance of halal depends not only on the substance of Islamic requirements, but also on the institutions empowered to interpret, certify, verify and recognise compliance.

This development raises a deceptively simple question: **Who governs the halal economy?**

The question matters because there is no single institutional answer. A halal product may be assessed by a certification body, the certification body may itself be subject to accreditation or regulatory approval, and the resulting certificate may subsequently require recognition by an authority in the destination market. Different jurisdictions allocate these functions differently. Religious authorities may exercise direct regulatory powers; accreditation agencies may provide institutional assurance regarding conformity assessment bodies; and food-control authorities may determine whether foreign certification bodies can operate within an import-control framework. Consequently, the legal architecture of halal is shaped not only by standards, but by the distribution of institutional authority.

Singapore offers a particularly clear example of a regulatory architecture in which religious authority and statutory regulation are closely connected. MUIS, the Islamic Religious Council of Singapore, is a statutory body established under the Administration of Muslim Law Act (AMLA). MUIS states that it provides halal certification services and regulates the halal industry in Singapore. Under section 88A of AMLA, MUIS has statutory authority concerning halal certification, while section 88AA empowers it to recognise foreign halal certification bodies. A certificate issued by a recognised foreign halal certification body has the same effect and validity as a certificate issued by MUIS, subject to the statutory framework. (Majlis Ugama Islam Singapura [MUIS], 2026a, 2026b). (Fhcb)

The foreign-recognition dimension has become increasingly important as Singapore relies on imported halal products and ingredients. MUIS does not itself certify food manufactured overseas; instead, imported halal products depend on certification bodies recognised by MUIS in their respective countries. Its current Foreign Halal Certification Bodies (FHCB) framework evaluates the ability of overseas bodies to implement standards aligned with Singapore's halal requirements. The enhanced framework includes personnel assessment, documentary review, risk assessment, recognition for three years and annual reporting requirements (MUIS, 2026b). (Majlis Ugama Islam Singapura)

Türkiye presents a different institutional configuration. The establishment of the Halal Accreditation Agency (HAK) created a dedicated institutional mechanism for the accreditation of halal conformity assessment bodies. HAK describes halal accreditation as the assessment, accreditation and monitoring of the competence of halal conformity assessment bodies against applicable national regulations, international standards and technical requirements. Its accreditation framework incorporates OIC/SMIIC standards as well as relevant ISO standards (Halal Accreditation Agency [HAK], 2026a). (https://english.hak.gov.tr)

The contemporary operation of this system also demonstrates its international reach. HAK's official register, updated on 14 September 2026, lists accredited halal conformity assessment bodies in Türkiye and numerous foreign jurisdictions. Its scopes include OIC/SMIIC 1:2019 for food, OIC/SMIIC 4:2018 for cosmetics and OIC/SMIIC 6:2019 for catering, among others. The register includes bodies in Europe, Asia, Africa, Australia and the Americas, illustrating how accreditation can

function beyond the territory of the accrediting state (HAK, 2026b). (https://english.hak.gov.tr)

Qatar provides a third institutional configuration. Rather than establishing a structure identical to either MUIS or HAK, Qatar incorporates halal certification into a broader state-administered food-control system. The Ministry of Public Health's Food Safety and Environmental Health framework includes the approval of Islamic bodies and other actors involved in halal certification, while its Global Partners System provides a mechanism through which official authorities and third-party bodies issuing halal certificates can register with the Qatari authorities (Ministry of Public Health [MOPH], 2026a, 2026b).

The Qatari framework is particularly relevant to cross-border trade because the regulatory significance of a halal certificate is linked to the approval status of the issuing body. The Qatari system maintains an official list of approved halal bodies, while its regulatory guidance requires halal or halal-slaughter certificates for relevant imported products from authorised Islamic organisations. Importantly, the relationship between Qatar and Türkiye demonstrates that these institutional arrangements can interact across borders. HAK reports that a memorandum of understanding concluded with the Qatari Ministry of Public Health in October 2022 established cooperation in halal quality infrastructure and that halal certificates issued by certification bodies accredited by HAK are accepted by Qatar under that arrangement (HAK, 2026c). (https://english.hak.gov.tr)

These three jurisdictions therefore offer more than three examples of halal certification. They provide a comparative setting for examining different distributions of regulatory authority. Singapore combines statutory religious authority with certification and foreign-body recognition. Türkiye places accreditation at the centre of institutional assurance for halal conformity assessment. Qatar incorporates halal certification bodies into a state food-control and market-access framework. The comparison consequently allows the analysis to move beyond the familiar question of whether a product is halal and toward the institutional question of **how halal status acquires legal and regulatory significance**.

This question has become increasingly relevant to international trade. Recent scholarship has shown that halal-related measures may raise issues concerning certification, labelling, traceability, recognition of foreign certification and accreditation bodies, procedural requirements and the use of international standards within the WTO framework (Mansoor, 2025; van der Meulen & Vellema, 2022). (DOI) These concerns do not mean that halal regulation is inherently incompatible with international trade. Rather, they demonstrate that the regulatory design of halal measures can influence the conditions under which products and certification bodies gain access to foreign markets.

Recent comparative research also confirms that differences between national halal frameworks remain relevant to international trade. A 2026 comparative review of Malaysia, Singapore and Indonesia, for example, identifies differences in halal standards and certification frameworks as a source of complexity for producers operating across borders (Zhang et al., 2026). (DOI) The contribution of the present study is not therefore to claim that comparative halal regulation has been neglected altogether. Its focus is narrower: it examines the **distribution of regulatory authority** across different institutional layers and asks how this distribution shapes the legal architecture of a global halal market.

The central research question is:

How do Singapore, Türkiye and Qatar allocate and exercise legal and institutional authority over the halal economy, and what do their different arrangements reveal about the emerging regulatory architecture of the global halal market?

Three subsidiary questions guide the analysis. First, how are religious authority, public authority, standardisation, certification and accreditation organised within each jurisdiction? Second, how do these arrangements determine the regulatory position of domestic and foreign halal certification bodies? Third, what do the three cases reveal about the relationship between national regulatory autonomy and the internationalisation of halal governance?

The paper does not seek to identify a superior national model. Such a ranking would obscure the institutional differences that make the comparison analytically useful. Instead, the study examines the three jurisdictions as distinct configurations through which authority is organised and exercised. This approach also avoids treating standardisation, certification, accreditation and recognition as interchangeable concepts. Each performs a different regulatory function, and the way in which these functions are institutionally connected helps determine the legal meaning of halal certification.

The paper argues that the global halal economy should therefore be understood as a **multi-layered regulatory space** rather than as a single certification system. Religious norms provide substantive foundations, but their practical and legal consequences depend on institutional mechanisms that translate those norms into standards, conformity assessment procedures, accreditation decisions, certification practices and market-access requirements. The emerging global halal market is consequently shaped by interaction among institutions rather than by the existence of one universally accepted governance model.

2. Methodology and Comparative Analytical Framework

This study adopts a comparative legal and institutional methodology. The purpose is not to measure the performance of Singapore, Türkiye and Qatar, but to identify how each jurisdiction constructs and distributes regulatory authority within its halal system.

The analysis relies primarily on documentary legal research. Official legislation, regulatory instruments, institutional rules, accreditation frameworks, recognition procedures and current registers of halal certification or conformity assessment bodies constitute the principal sources. These materials are complemented by recent peer-reviewed scholarship addressing halal certification, international trade, standardisation and regulatory governance. Priority is given to current official sources where institutional arrangements may change over time.

The comparison is organised around four analytical dimensions: **(1) legal basis and institutional authority; (2) certification and conformity assessment; (3) accreditation, recognition or approval of foreign bodies; and (4) implications for cross-border market access**. This framework allows the analysis to distinguish between the substantive content of halal requirements and the institutional mechanisms through which those requirements acquire regulatory effect.

The study treats the following sequence as an analytical, rather than necessarily linear, architecture:

Halal norms → standardisation → conformity assessment → certification/accreditation → recognition or regulatory approval → market access.

The purpose of this sequence is to identify where regulatory authority is located at different stages. The three jurisdictions may connect these stages differently, and those differences constitute the principal object of comparison.

3. Results

3.1 Singapore: Statutory Religious Authority and Foreign Certification Recognition

Singapore's halal governance framework places MUIS at the centre of both domestic certification and the recognition of foreign halal certification bodies. This institutional position is legally grounded in AMLA rather than merely administrative practice. MUIS therefore occupies a distinctive position in which religious authority is integrated into a statutory regulatory framework (MUIS, 2026a).

The foreign-certification mechanism is particularly significant. MUIS recognises overseas certification bodies only after assessing their ability to implement halal standards compatible with Singapore's requirements. The current framework includes assessment of management, Shariah and technical personnel, documentary review and risk classification. Recognition is granted for three years, with annual reporting obligations. This makes recognition an active regulatory relationship rather than a one-time administrative listing (MUIS, 2026b). (Majlis Ugama Islam Singapura)

Singapore therefore demonstrates how a religious institution can operate simultaneously as a certifying authority and as a regulator of foreign certification bodies. The key feature is not simply centralisation, but the legal capacity to determine when an external certification becomes sufficiently reliable for the domestic market.

3.2 Türkiye: Accreditation as Institutional Assurance

Türkiye's architecture is structurally different. The creation of HAK separates the accreditation function from the certification function and places the competence of halal conformity assessment bodies within a dedicated accreditation framework. This creates an institutional layer between the body issuing a certificate and the market that relies upon it.

HAK's current register demonstrates the international dimension of this approach. Accredited conformity assessment bodies are located both inside and outside Türkiye, and accreditation scopes are linked to OIC/SMIIC standards covering food, cosmetics, catering and other areas (HAK, 2026b). (https://english.hak.gov.tr)

The Turkish model therefore gives accreditation a prominent role in producing regulatory confidence. The certificate is not treated as sufficient in itself; the institutional competence of the body issuing the certificate becomes an object of formal assessment.

This architecture also has a cross-border dimension. HAK's cooperation with Qatar demonstrates that accreditation can become part of an intergovernmental mechanism through which certificates issued by accredited bodies acquire acceptance in another national market (HAK, 2026c). (https://english.hak.gov.tr)

3.3 Qatar: State Food Control and Approval of Halal Bodies

Qatar approaches halal governance through a broader food-control architecture. The Ministry of Public Health's system includes a mechanism for registering official authorities and third-party bodies

that issue halal certificates and maintains a public list of approved halal bodies (MOPH, 2026a, 2026b).

The legal significance of certification therefore depends on the status of the issuing organisation within the Qatari regulatory framework. This is particularly important for imported products for which halal documentation is required. Qatar's system consequently connects halal certification directly with food-control and market-entry functions.

The relationship with Türkiye illustrates the possibility of institutional interoperability without complete institutional uniformity. Qatar may recognise certification issued by bodies accredited through HAK under the bilateral cooperation framework, while retaining its own authority over the conditions applicable to products entering its market (HAK, 2026c). (https://english.hak.gov.tr)

4. Discussion

The comparison reveals three different ways of organising regulatory confidence in halal certification.

Singapore places substantial authority in a statutory Islamic institution that combines domestic certification with recognition of foreign certification bodies. Türkiye gives a dedicated accreditation institution a central role in assessing the competence of conformity assessment bodies. Qatar embeds approval of halal bodies within a state food-control system linked directly to the importation of relevant products.

These differences should not be understood as evidence of three isolated systems. On the contrary, all three are increasingly connected through international standards, foreign certification bodies, accreditation mechanisms and bilateral or multilateral cooperation. The result is a regulatory environment in which national authority remains significant while cross-border interoperability becomes increasingly necessary.

The comparison also reveals why **governance** provides a broader analytical lens than certification alone. Certification answers whether a particular product or service has been assessed as halal under a particular scheme. Governance asks who defines the relevant framework, who supervises the certifier, who can recognise an external body, and who ultimately determines the regulatory consequences of certification.

This distinction becomes particularly important when halal requirements intersect with international trade. WTO-oriented scholarship identifies recognition of foreign halal certification and accreditation bodies among the recurring regulatory issues surrounding halal measures (Mansoor, 2025). (DOI) The legal challenge is therefore not necessarily to eliminate national differences, but to manage those differences in a manner that maintains legitimate public and religious objectives while reducing unnecessary barriers to cross-border trade.

The three cases also suggest that convergence does not require institutional uniformity. A country may preserve its own religious and regulatory institutions while developing mechanisms for cooperation with foreign accreditation or certification systems. The Qatar–Türkiye relationship illustrates this possibility: accreditation performed by HAK can acquire relevance within the Qatari market through an institutional cooperation framework, while Qatar retains regulatory authority over its own import regime (HAK, 2026c). (https://english.hak.gov.tr)

The emerging architecture may therefore be described as **interoperable pluralism**: different national systems retain their institutional identities while developing mechanisms through which certificates, accreditation decisions and regulatory assurances can travel across borders. The principal challenge is to establish sufficient confidence between systems without assuming that confidence requires identical institutional structures.

5. Conclusion

The global halal economy is increasingly governed through a network of institutions rather than a single regulatory authority. The comparison of Singapore, Türkiye and Qatar demonstrates that halal governance can be organised through different combinations of statutory religious authority, accreditation, state approval and food-control mechanisms.

Singapore demonstrates the regulatory capacity of a statutory Islamic institution to combine domestic certification with structured recognition of foreign certification bodies. Türkiye demonstrates the institutionalisation of halal accreditation as a distinct mechanism for assuring the competence of conformity assessment bodies. Qatar demonstrates how halal certification can be incorporated into a state-administered food-control and import framework, while also participating in cross-border institutional cooperation.

These differences do not necessarily prevent the emergence of a global halal market. They instead make the question of regulatory interoperability increasingly important. The future development of halal trade may depend less on eliminating institutional diversity than on creating reliable mechanisms through which different systems can understand, assess and recognise one another.

The central conclusion is therefore that the legal architecture of the global halal economy should not be reduced to the existence of halal standards or certificates. Its deeper structure lies in the allocation of authority among the institutions that define, assess, certify, accredit, recognise and regulate halal compliance. **Who governs the halal economy?** The comparison suggests that the answer is distributed across these institutional layers. Understanding their interaction is essential for analysing how halal moves from a religious norm to a regulated condition of participation in global markets.

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(O-42) QURANIC PRINCIPLES FOR A MUSLIM CONSORTIUM TO SECURE CRITICAL HALAL INGREDIENTS

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Abstract

A sustainable halal economy rests on something easy to overlook: reliable access to the ingredients that halal industries use every day. Many producers in Muslim countries still rely on a small number of outside suppliers for critical ingredients such as gelatin, collagen, enzymes and glycerin. That reliance raises costs, leaves supply chains open to disruption and makes halal assurance harder. Drawing on a narrative review of Quranic texts, academic literature, policy documents and international trade statistics, this conceptual paper asks how five Quranic principles, taʿāwun (cooperation in righteousness), amānah (trust and accountability), ʿadl (justice), the avoidance of isrāf (wasteful excess) and maṣlaḥah (public welfare), can support a consortium of Muslim producers and countries.

The review shows an uneven picture. Member states of the Organisation of Islamic Cooperation (OIC) already supply a large share of the world's glycerol exports, but only a small share of its gelatin and enzymes. Several OIC states also have large livestock and aquaculture sectors whose by-products are seldom turned into high-value ingredients. On this basis, the paper proposes a conceptual framework that links five Quranic principles to five consortium mechanisms and four expected outcomes, together with a halal supply chain consortium model connecting source countries, a coordinating foundation or research centre, supply chain networks and manufacturers. Its central argument is that making critical ingredients is only half the task: a supply chain consortium is needed so that what is produced in Muslim countries actually reaches the manufacturers who need it. Malaysia's halal industrial parks offer a working example of coordinated clustering.

The paper concludes that Quranic principles can guide cooperation that pays off both economically and environmentally. By pooling investment and using resources responsibly, a Muslim consortium could make ingredient supply more secure, reduce dependence on outside suppliers, cut waste and support sustainable growth across the global halal economy.

Keywords: Quranic principles, Muslim consortium, critical halal ingredients, halal supply chain, resource utilisation, narrative review

1. Introduction

1.1 Overview

The halal economy is now a major global market. The *State of the Global Islamic Economy 2024/25* report estimates that Muslim consumers spent about US$2.43 trillion in 2023 across six sectors, including halal food and beverages (Salaam Gateway, 2025a). In the same year, OIC member states

imported US$407.75 billion of these products, and food made up 72% of that total, or US$293.58 billion (Salaam Gateway, 2025b).

Less visible is the industry's dependence on ingredients. Gelatin, collagen, enzymes and glycerin turn up in food, medicines, cosmetics and supplements, and their halal status depends on where they come from. Gelatin and collagen are made from animal tissue; glycerin can come from animal fat or plant oil; enzymes may be animal or microbial in origin. Gelatin is often described as the most studied ingredient in halal research, yet verifying its source is still slow and expensive (Hameed et al., 2018). One industry analysis put the share of gelatin made from halal sources at less than 3% (Cochrane, 2016).

Regulation is raising the stakes. Indonesia's mandatory halal certification for cosmetics, traditional medicines and health supplements is due to take effect in October 2026, and auditors are now looking closely at raw and supporting materials. As a senior official of LPPOM, Indonesia's halal inspection body, put it, "even a single material with unclear origin can compromise the halal status of the entire product" (LPPOM, 2026).

Most of the literature deals with authenticating ingredients and protecting integrity within individual supply chains. Far less has been written about collective, supply-side solutions, in which Muslim countries work together to make critical ingredients themselves, or about the religious and ethical case for doing so. Distribution is a further gap. A country can be a leading producer or exporter of an ingredient while manufacturers in other Muslim countries still struggle to obtain certified supply. None of the sources reviewed described a dedicated mechanism linking producers of critical ingredients in one Muslim country with the manufacturers who need them in another.

This paper sets out to fill that gap. It examines how Quranic principles can underpin a halal supply chain consortium of Muslim producers and countries, so that critical ingredients made in the Muslim world reach the manufacturers who need them. Three questions guide the discussion:

1. What is the current supply position of OIC member states for critical halal ingredients?
2. Which Quranic principles support cooperation in securing these ingredients?
3. How can these principles be translated into a practical consortium model?

Section 2 explains the narrative review method, and Section 3 reviews what is known about critical ingredients, the OIC supply position and existing forms of cooperation. Section 4 sets out the relevant Quranic principles. Sections 5 and 6 present the conceptual framework and the proposed consortium model, Section 7 discusses the implications, and Section 8 concludes.

Conceptual background and academic definitions

Halal and Tayyiban

"Halal" refers to actions or items that are permissible under Islamic law (Raja Yusof, 2013). In the Quran it is often paired with "tayyib", meaning pure, clean, wholesome and of good quality. For the food industry, *halalan tayyiban* means that a product is not only religiously permissible, for example free of pork and alcohol, but also safe, nutritious and ethically produced (Annabi et al., 2017). Read this way, living by the halal extends to a whole normative space in which conduct is shaped by respect

for divine limits and for human well-being (Bergeaud-Blackler, 2015).

Halal integrity

Halal integrity is the ongoing assurance that materials and products meet Shariah requirements and stay protected from prohibited substances, contamination, deception and undocumented processing at every stage of the supply chain (Soon et al., 2017; Tieman, 2013). It covers both the product's actual halal status and the control system that demonstrates it.

Critical ingredients

Halal critical ingredients are ingredients or processing inputs whose source, processing, additives, contact materials or handling can, if uncertain, affect a product's halal status, safety or certification. Gelatin, enzymes, emulsifiers, flavours, colourants, cultures and pharmaceutical excipients are typical examples. The category is defined by risk: an ingredient counts as critical when failing to verify it could invalidate a product or lead to costly recalls, loss of certification or reputational damage (Nazaruddin et al., 2023; Saidin, 2023).

Halal Supply Chain (HSC)

The halal supply chain is more than a technical arrangement; it is an ethical system that calls for transparency, justice and sustainability (Maharani et al., 2023). It also draws on green supply chain practices, which aim to reduce environmental harm while maintaining religious compliance (Mu'is et al., 2023).

Muslim Consortium

A Muslim consortium is a collaborative arrangement in which several organisations join forces to strengthen their competitive position. In an Islamic setting, the collaboration rests on *ta'awun* (mutual assistance) and is designed to share risks and rewards fairly. The consortium can act as a central body for procurement, quality assurance and distribution, achieving economies of scale that no single firm could reach on its own. It can also serve as a platform for what has been called "halal geoeconomics", giving Muslim nations greater strategic autonomy within global value chains (Anggraini et al., 2023).

2. Methodology

2.1 Research design

This conceptual paper is built on a narrative review. Unlike a systematic review, which pools results statistically, a narrative review draws together a wide range of sources to build an argument and generate new conceptual insight (Green et al., 2006). The approach fits this study because the evidence comes in very different forms: religious texts, academic research, policy documents and trade statistics. No primary data were collected.

2.2 Sources

Four categories of sources were reviewed:

1. **Quranic texts and exegesis.** Verses relating to cooperation, trust, fairness, resource use, waste, partnership and the halal mandate, read with the classical exegesis of Ibn Kathir, *Tafsir al-Qur'an al-'Azim*.

2. **Academic literature** on halal ingredients, gelatin authentication, halal supply chain integrity and by-product use.
3. **Policy and industry documents**, including reports of the Standards and Metrology Institute for Islamic Countries (SMIIC), official statements on Malaysia's halal industrial parks, the *State of the Global Islamic Economy* report and industry news.
4. **Trade and production statistics**: 2023 export data from the UN Comtrade database (accessed through TrendEconomy) for nine product codes in the World Customs Organization's Harmonized System (HS) 2022 edition, together with FAO and national livestock and aquaculture statistics.

2.3 Search and selection

Academic sources were found through Google and scispace, using combinations of the keywords "halal ingredients", "halal gelatin", "halal supply chain", "collagen", "glycerin", "OIC cooperation" , “Muslim Consortium” and "halal park". Sources published mainly between 2010 and 2026, in English or Malay, were considered, and any source that addressed at least one of the three research questions was included.

Quranic verses were located through a thematic search of key concepts: *ta'awun* (cooperation), *amanah* (trust), *'adl* (justice), *israf* and *tabdhir* (excess and waste), *khulata'* (partners), *an'am* and *manafi'* (livestock and their benefits) and *halalan tayyiban*. Each verse was logged in a structured form and classed either as direct textual evidence (*nas*) or as inferential evidence (*istinbat* or analogy), the latter where the verse's original context differs and its use here is an extension.

2.4 Synthesis

The sources were synthesised around four themes: the problem of critical halal ingredients, the supply position of OIC member states, existing models of cooperation, and the Quranic principles that bear on cooperation. This synthesis then informed the conceptual framework (Section 5) and the consortium model (Section 6).

2.5 Limitations of the method

A narrative review is selective and interpretive, so some relevant sources may have been missed. Trade codes do not separate halal from non-halal sources, and collagen has no code of its own, so the trade data show supply patterns only roughly. Several OIC states, among them Sudan, Chad and Iran, did not report trade data for 2023. Lastly, applying some verses to a modern consortium involves interpretation, and these applications are presented as *istinbat* rather than as explicit textual instruction.

3. Literature review

3.1 Critical halal ingredients and the problem of source

In halal terms, an ingredient is critical when its permissibility depends on a source that becomes hard to verify once it has been processed. Gelatin is the clearest case. Hameed et al. (2018) describe seven families of methods for authenticating gelatin's source, from DNA-based to spectroscopic techniques, but note that all of them are slow, need costly equipment and are weakened by changes that occur

during processing. Collagen, glycerin and enzymes raise much the same questions, since each can be derived from animals.

In practice, this means halal assurance now depends more on supply chain transparency than on testing the finished product. Indonesia's approach to mandatory certification shows the shift: auditors look past finished goods to supporting materials such as capsules, emulsifiers and additives, and firms are advised to map their entire supply chains and check that their suppliers are halal-certified (LPPOM, 2026). When these ingredients come from outside the Muslim world, that mapping is harder and supply is less secure.

3.2 The supply position of OIC member states

Trade data show an uneven picture. Table 1 gives the estimated OIC share of world exports in 2023, calculated by adding up the reported exports of each member state.

Table 1: The Estimated Share Of OIC Member States In World Exports In 2023

Ingredient or raw material (HS code)	OIC share of world exports, 2023	Leading OIC exporters
Refined glycerol (2905.45)	~41%	Indonesia (#1 worldwide), Malaysia (#4)
Crude glycerol (1520)	at least 37%	Indonesia (#1), Malaysia (#5)
Gelatin (3503)	~7.5%	Turkey (#8), Pakistan (#18)
Bones (0506)	~6.9%	Pakistan (#6)
Enzymes (3507)	~1.6%	Turkey, Malaysia, UAE
Raw bovine, buffalo and equine hides (4101)	~0.9%	Pakistan

Source: authors' calculation from UN Comtrade data via TrendEconomy (n.d.). Shares are estimates; several OIC states do not report trade data.

OIC states are already leading glycerol exporters, thanks largely to the palm oil industries of Indonesia and Malaysia. Yet they account for only a small share of gelatin and enzyme exports, even though several have very large livestock herds. Pakistan alone reported 61.96 million cattle, 49.1 million buffalo and 91.8 million goats in fiscal year 2026 (ProPakistani, 2026), and FAO data rank Indonesia, Bangladesh and Egypt among the world's ten largest aquaculture producers (FAO, 2024). Even so, the OIC's combined share of world exports of raw bovine hides is below 1%. The hides, bones and fish skins from which gelatin and collagen can be made appear either to go to other uses, such as leather, or to remain unprocessed.

3.3 Existing models of cooperation

Two initiatives show that Muslim countries can and do cooperate on halal matters.

Standards harmonisation. The Standards and Metrology Institute for Islamic Countries (SMIIC) was set up in 2010 to harmonise standards among OIC member states and remove technical barriers to trade (SMIIC, n.d.). By the end of 2024 it had 48 member states, three of them observers, and had published 58 OIC/SMIIC standards, 20 of which deal with halal issues. It was also working with the Islamic Forum for Halal Accreditation Bodies towards mutual recognition of halal certificates (SMIIC, 2025).

Industrial clustering. Malaysia has built 22 halal industrial parks, 14 of which hold Halal Malaysia (HALMAS) status from the Halal Development Corporation. By 2022 the parks had drawn more than

RM16 billion in investment and were home to 295 companies, 42 of them multinationals (Ministry of Finance Malaysia, 2022). At the level of individual firms, Turkey's Halavet Food invested US$25 million in a 1,500-tonne bovine gelatin plant to expand its halal gelatin output (Salaam Gateway, 2021).

3.4 Gaps in the literature

Three gaps emerge from the review. Research on critical ingredients has focused on authentication and certification rather than on securing supply. Cooperation among Muslim countries has centred on standards (SMIIC) and national clusters (Malaysia's halal parks), not on joint cross-border production of particular ingredients. And while Islamic principles are often invoked in halal research, few of the sources reviewed turn them into a model for institutional cooperation between countries. The rest of this paper takes up these gaps.

4. Quranic principles for cooperation

Five core principles emerged from the review, matching the aims of this paper, together with supporting verses on the halal mandate. Quoted verses follow the Saheeh International translation; other verse meanings are the authors' summaries.

4.1 Cooperation (ta'awun)

The key text is Al-Ma'idah 5:2, which commands believers to "cooperate in righteousness and piety, but do not cooperate in sin and aggression." Supplying the Muslim community with halal ingredients falls squarely within righteousness (*al-birr*), so organised cooperation towards that end has direct support. Ali 'Imran 3:103 urges believers to hold together and not divide, and Al-Anfal 8:46 warns that quarrelling leads to failure and a loss of strength. Al-Hujurat 49:13 adds that God "made you peoples and tribes that you may know one another", a verse that can be read as encouraging countries to complement one another's resources and expertise.

4.2 Trust (amanah)

An-Nisa' 4:58 commands that trusts be returned to those entitled to them. In a supply chain, both the accuracy of an ingredient's halal status and the reliability of its supply are trusts owed to manufacturers and consumers. Al-Qasas 28:26 describes the best person to hire as "the strong and the trustworthy", and in Yusuf 12:55 the Prophet Yusuf presents himself as a guardian who is both trustworthy and knowledgeable. Taken together, these verses suggest how those who run the consortium should be chosen.

4.3 Fairness ('adl)

An-Nahl 16:90 commands justice and excellence (*ihsan*). Ar-Rahman 55:7–9 and Al-Mutaffifin 83:1–3 condemn cheating in weights and measures, which supports open auditing and traceability. Al-Hashr 59:7 warns against wealth circulating only among the rich. For a consortium, this means costs and benefits should be shared fairly, so that less developed member states gain as well.

4.4 Avoidance of israf (wastefulness)

The Quran forbids *israf* again and again; the word means excess, or going beyond proper limits in using resources. Al-A'raf 7:31 commands: "eat and drink, but be not excessive. Indeed, He likes not

those who commit excess." Al-An'am 6:141 repeats the command in the context of the harvest, tying it directly to agricultural produce. Al-Furqan 25:67 describes the servants of the Most Merciful as "those who, when they spend, do so not excessively or sparingly but are ever, between that, [justly] moderate."

Closely related is *tabdhir*, the squandering of wealth. Al-Isra' 17:26–27 condemns it in strong terms, declaring that "the wasteful are brothers of the devils". Taken together, *israf* and *tabdhir* make waste a moral failing, not merely an economic one.

The principle bears on the consortium in two ways. Leaving hides, bones and fish skins unused when they could become gelatin and collagen is itself a form of waste, all the more so while Muslim countries import those same ingredients. Waste also occurs when member states each build small, duplicate facilities or compete for the same scarce raw materials. A consortium that coordinates needs and pools investment tackles both problems. The principle also gives the consortium an environmental dimension, in line with Al-A'raf 7:56, which forbids spreading corruption on earth after it has been set right.

4.5 Maṣlaḥah and Maqasid al-Shariah.

A *maqasid*-informed model asks whether supply chain decisions protect religion, life, intellect, progeny and property, and recent sustainability scholarship widens the lens to include social and environmental welfare (Haq & Wahab, 2019). The consortium therefore treats halal integrity, product safety, livelihoods, environmental stewardship and the protection of property as connected outcomes, not as separate compliance boxes to tick.

4.6 The Halal Mandate.

Al-Ma'idah 5:3 and Al-An'am 6:145 prohibit carrion, blood and pork, and Al-Baqarah 2:168 commands eating what is lawful and good (*halalan tayyiban*). These verses explain why an ingredient's source matters, and why securing halal sources is a religious concern as much as an economic one.

Table 2 summarises how these verses were classified.

Table 2: Summary of the Quranic principles for cooperation

Principle	Primary verse	Evidence type
Cooperation	Al-Ma'idah 5:2	Direct
Trust	An-Nisa' 4:58	Direct
Fairness	An-Nahl 16:90	Direct
Avoidance of israf	Al-A'raf 7:31; Al-Isra' 17:26–27	Direct
Maṣlaḥah	al-Anbiya’ 21:107,al-Hajj 22:39–40 al-Ma’idah 5:32, al-Ma’idah 5:90–91, al-Isra’ 17:32, al-Baqarah 2:188, al-Nisa’ 4:29	Inferential
Halal mandate	Al-Ma'idah 5:3	Direct

5. Conceptual framework

Figure 1 draws the findings of Sections 3 and 4 together. Starting from the supply problem identified in Section 3, it reads from left to right: five Quranic principles guide five consortium mechanisms, which in turn deliver four expected outcomes, all resting on the halal mandate.

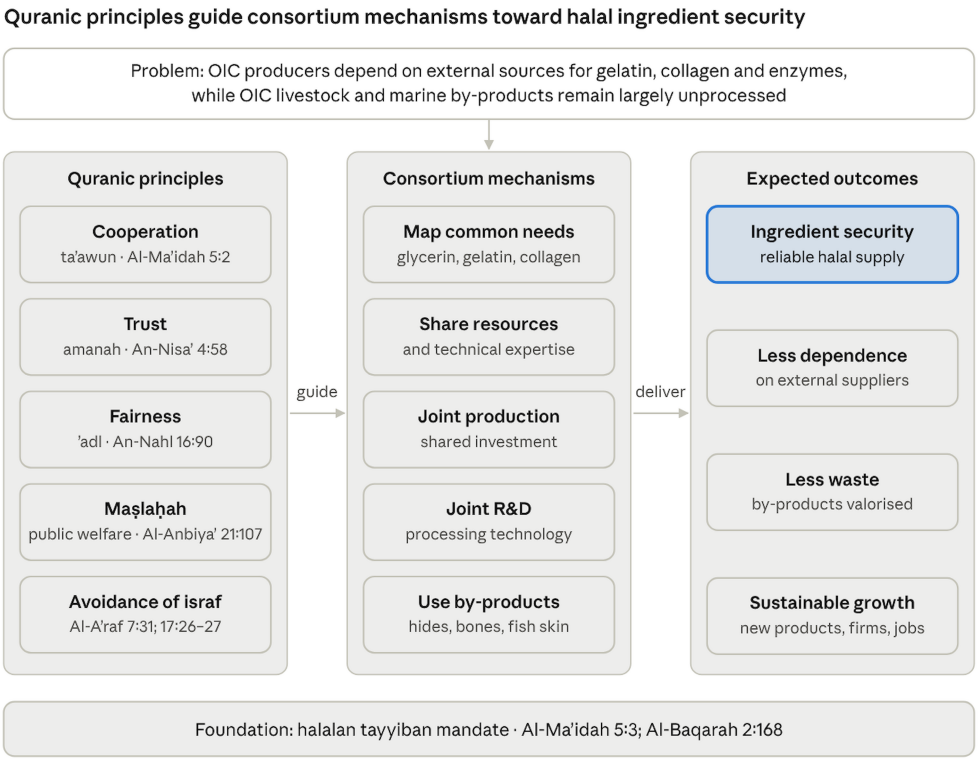

Figure 1 · Conceptual framework: 5 principles, 5 mechanisms, 4 outcomes

Table 3: The Suggested Mechanisms to Produce Outcomes from Core Principles

Principle	Mechanisms it chiefly guides
Cooperation (Al-Ma'idah 5:2)	Mapping common ingredient needs, starting with glycerin, gelatin and collagen; sharing resources and expertise
Trust (An-Nisa' 4:58)	Reliable, traceable sourcing among members; selecting capable and trustworthy managers (Al-Qasas 28:26)
Fairness (An-Nahl 16:90)	Joint production with fair sharing of costs and benefits, so that gains reach less developed members (Al-Hashr 59:7)
Maṣlaḥah (Al-Anbiya' 21:107)	Judging joint investments by their contribution to public welfare, including product safety, livelihoods and the environment; developing under-used livestock and marine resources through joint R&D on processing technology
Avoidance of israf (Al-A'raf 7:31; Al-Isra' 17:26–27)	Processing by-products instead of discarding them; pooling investment to avoid duplicate facilities among members

The mechanisms lead to the outcomes. Mapping needs and sharing resources cut duplication and build *ingredient security*. Joint production reduces *dependence* on outside suppliers. Putting by-products to use reduces *waste*. Alongside joint R&D, these mechanisms support *sustainable growth* through new products, firms and jobs.

6. Proposed consortium model

The framework takes practical form in a halal supply chain consortium operating across OIC member states. Its purpose is straightforward: critical halal ingredients made in one Muslim country should be able to reach the manufacturers who need them in another. Figure 2 shows how the concept works,

with a coordinating centre at its core.

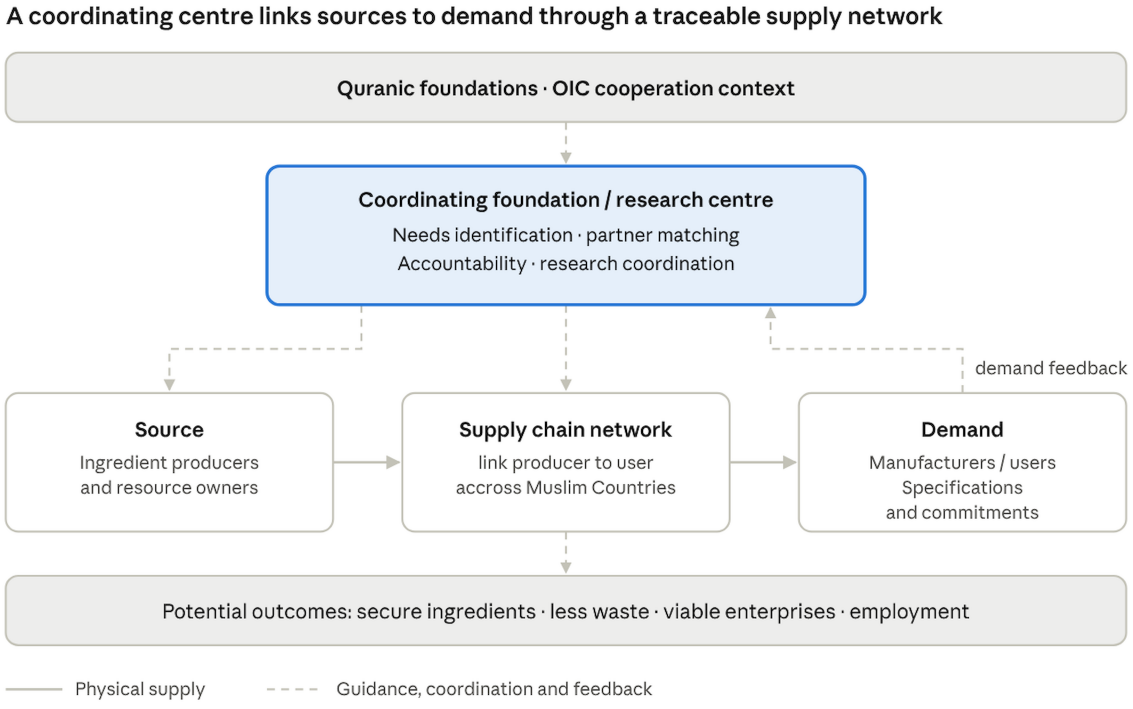

Figure 2 · Proposed halal supply chain consortium model

Solid arrows show the physical flow of ingredients; dashed arrows show guidance, coordination and feedback.

1. **Quranic foundations and OIC cooperation context.** The principles set out in Section 4 and the existing framework of cooperation among OIC member states guide the consortium as a whole and the work of the coordinating centre in particular.
2. **Coordinating foundation or research centre.** Identifies common ingredient needs across member states, such as gelatin, enzymes, glycerin and collagen. It matches partners in source and demand countries, holds members accountable to agreed commitments in keeping with the principle of trust (*amanah*), and coordinates joint research on processing technology.
3. **Source.** Ingredient producers and resource owners in OIC states. The trade data in Section 3.2 suggest Indonesia and Malaysia for glycerin, and Turkey and Pakistan for gelatin. Countries with large livestock or aquaculture resources are potential sources of by-products for gelatin and collagen.
4. **Supply chain network.** Processes raw materials into ingredients and manages logistics, traceability and distribution, so that supply reaches the intended users in Muslim countries with verifiable halal status.
5. **Demand.** Halal food, pharmaceutical and cosmetic manufacturers and other users. They set ingredient specifications, make purchase commitments, and feed their changing needs back to the coordinating centre.

6. **Potential outcomes.** Secure ingredients, less waste, viable enterprises and employment.

6.1 The central role of the supply chain network

The concept works as a loop. Manufacturers and other users across the OIC state their demand for critical ingredients, along with their specifications and commitments. The coordinating foundation or research centre pulls these needs together (for gelatin, enzymes, glycerin or collagen, for instance) and matches them with producers and resource owners in source countries. The supply chain network then processes, traces and distributes the ingredients to the manufacturers who need them, and feedback on demand flows back to the centre.

Of all the components, the supply chain network is the one that turns production into security. Making an ingredient somewhere in the Muslim world does not guarantee that a manufacturer in another Muslim country can obtain it in the quantity needed and with verifiable halal status. The network matters for three reasons:

1. **Matching supply with demand.** Without a network, ingredients produced in one OIC state may be sold to other markets while manufacturers elsewhere in the OIC continue to rely on external suppliers. The network links each source to the users who need it.
2. **Preserving halal integrity.** As Indonesia's approach to mandatory certification shows, a single material of unclear origin can compromise the halal status of a whole product (LPPOM, 2026). A network that traces ingredients from producer to user protects halal assurance at every step, in keeping with the principle of trust (*amanah*, An-Nisa' 4:58).
3. **Making joint investment viable.** Investors are more likely to fund new gelatin or collagen plants when buyers are assured. By connecting producers with known demand, the network reduces the risk of joint production and gives practical form to the cooperation commanded in Al-Ma'idah 5:2.

Malaysia's halal parks show what can be gained by bringing producers together within one country. The proposed consortium carries the same logic across borders, joining producing and manufacturing countries into a single halal supply chain.

6.1.1 Waste-reduction and growth mechanisms

Consider a joint procurement programme for halal gelatin and enzymes. Members begin by pooling their demand forecasts and grading suppliers by source and processing risk. The consortium then prequalifies at least two suppliers, commissions shared testing and links each approved batch to a digital certificate. Manufacturers receive only what confirmed production requires, plus a buffer sized to the risk. If a batch is rejected, the digital record pinpoints the affected lots and customers, so there is no need for a broad and costly recall.

Shared cold-chain and laboratory facilities in a halal industrial cluster offer a second example. Many SMEs cannot run their own laboratories or validated temperature-controlled storage. A consortium can provide these as shared services under transparent access rules, which cuts duplicated capital spending, raises utilisation and helps smaller firms meet evidence requirements. Waste falls through better storage, fewer expired materials and earlier detection of non-conforming batches.

6.2 Governance

In keeping with the principles in Section 4, the consortium would be run through consultation among its members (Asy-Syura 42:38), bound by clear agreements (Al-Ma'idah 5:1) and managed by people who are both capable and trustworthy (Al-Qasas 28:26). Its products would follow common halal standards, such as those developed by SMIIC.

6.3 Phased implementation

The consortium would be built in four phases, starting small with a few high-demand ingredients: glycerin, gelatin and collagen. In the first phase, formation, founding members agree on scope and governance, and the coordinating centre maps needs and existing capacity. In the second, the pilot, glycerin from existing producers is channelled to manufacturers in other member states, and supply arrangements for one further ingredient, such as gelatin, are tested. In the third, cluster integration, member states invest together in gelatin and collagen production from livestock and marine by-products, building on the clustering experience of Malaysia's halal parks. In the fourth, cross-border scaling, the consortium extends to more countries and ingredients through mutual recognition of certificates and shared data standards. Section 6.3.1 sets out each phase in more detail.

6.3.1 Implementation roadmap and evaluation

Phase 1: formation. Identify founding members, define the critical-ingredient scope, conduct a legal and Shariah review, and sign a member charter.

Phase 2: pilot. Select one or two ingredient categories; map the supply chain; establish supplier qualification, laboratory protocols, and a secure data architecture.

Phase 3: cluster integration. Connect the consortium with halal parks, shared logistics, SMEs, universities, Islamic-finance providers, and public agencies.

Phase 4: cross-border scaling. Negotiate mutual-recognition arrangements, multilingual data standards, dispute-resolution procedures, and interoperable certification evidence.

Progress could be measured through indicators such as the percentage of critical-ingredient batches with complete traceability; rejected-batch rate; material waste per unit of output; expired-stock rate; certification lead time; frequency of emergency freight; dual-source coverage; SME participation; procurement-cost variance; energy and cold-chain losses; number of halal-integrity incidents; export value; jobs created; and member trust scores.

7. Discussion and implications

7.1 Theoretical contribution

This paper moves the discussion of Islamic principles in the halal economy beyond individual firms and products to cooperation between countries. Earlier work has tended to use religious principles to justify halal requirements. Here they are used to design an institution: cooperation and trust shape how members work together, fairness shapes how costs and benefits are shared, the avoidance of *israf* shapes how resources are used, and *maṣlaḥah* shapes what gets produced and for whose benefit. Separating direct from inferential evidence also offers a transparent way of linking Quranic texts to modern institutional design.

7.2 Practical implications

Prioritise the supply chain network. Policymakers should see the supply chain network as the heart of the consortium, not an afterthought. Investing in production will secure ingredients only if certified materials can move reliably from producing to manufacturing countries. Early steps include mapping current flows of critical ingredients among OIC states, agreeing on common traceability requirements, and building logistics and certification links between source countries and manufacturers.

Start from existing strengths. Glycerin need not be treated as a production gap. Indonesia and Malaysia are already among the world's leading glycerol exporters, so glycerin can anchor the consortium early on; here the task is reliable, certified distribution among member states rather than new capacity.

Focus new investment on gelatin and collagen. This is where the gap is widest: OIC states have plenty of raw material but little processing capacity. Joint investment in plants located near livestock and fisheries resources could turn unused by-products into high-value ingredients.

Build on existing institutions. The consortium should complement existing bodies rather than duplicate them. SMIIC's halal standards and its work on mutual recognition of certificates could supply a common standard for consortium products, while Malaysia's halal parks offer a model for bringing producers, researchers and investors together in one place.

Finance in line with Shariah. Joint ventures could be structured through partnership contracts such as *musharakah*, in keeping with the prohibition of usury in Al-Baqarah 2:275.

7.3 Challenges

The model faces real obstacles. Member states differ widely in income, infrastructure and regulatory capacity, which makes fair sharing of costs and benefits hard in practice. Mutual recognition of halal certificates is still incomplete. Some raw materials, hides among them, already have established uses such as leather. And gaps in trade data, particularly for countries that do not report to UN Comtrade, leave the true supply potential of several states uncertain.

8. Conclusion

This paper asked how Quranic principles could support a consortium of Muslim producers and countries to secure critical halal ingredients. On the first research question, the review found that OIC member states are already strong in glycerol but weak in gelatin, enzymes and the processing of animal and marine by-products, despite their large raw material base. On the second, it identified five core Quranic principles: cooperation, trust, fairness, the avoidance of *israf* (wastefulness) and *maṣlaḥah* (public welfare), read in the light of the *maqasid al-shariah* and supported by verses on the halal mandate. On the third, it proposed a conceptual framework and a halal supply chain consortium model that links source countries, a coordinating centre, supply chain networks and manufacturers. One argument runs through the whole paper: the supply chain network is what turns production into security. Without it, critical ingredients made in one Muslim country may never reach the manufacturers in another who need them.

Quranic principles, in short, can guide cooperation with real economic and environmental value. By pooling investment and using resources responsibly, a Muslim consortium could make ingredient

supply more secure, reduce reliance on outside suppliers, cut waste and support sustainable growth across the global halal economy.

8.1 Limitations

As a narrative review, the paper is selective and interpretive and includes no primary data. The trade figures are approximate, because product codes do not identify halal sources and several OIC states do not report their trade. Applying some verses to a modern consortium rests on inference, and those applications should be read with that in mind.

8.2 Future research

Future studies could test the model through interviews with halal manufacturers, regulators and investors in OIC states; assess whether producing gelatin and collagen from specific by-products is technically and economically feasible in selected countries; and explore governance options for a cross-border consortium, including how it would relate to SMIIC and national halal authorities.

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(O-43) DO BANKS GAIN FROM TALKING ABOUT ARTIFICIAL INTELLIGENCE? DISCLOSURE AND PROFITABILITY IN ISLAMIC AND CONVENTIONAL BANKS

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Abstract

We examine whether artificial intelligence disclosure in bank annual reports is associated with profitability, and whether the association differs between Islamic and conventional banks. We assemble 2,681 English-language annual reports from 290 banks in 25 countries over 2015 to 2025. Artificial intelligence sentences are retrieved with a 69-term finance lexicon and validated by a transformer-based language classifier whose audited precision is 98.5 percent. The main sample contains 872 disclosing bank-years from 191 banks in 22 countries, complemented by a full panel of 2,029 bank-years. Pooled and within-bank fixed effects estimates are compared using a bank-clustered bootstrap and a within-between model. Across banks, a one standard deviation increase in the classifier-based disclosure score is associated with 0.065 percentage points higher return on assets. Within banks the coefficient falls to −0.014, and the bootstrap difference is significant, although the within-between test does not reject equal slopes. We find no detectable within-bank association and no difference in slopes between Islamic and conventional banks. Islamic banks are less likely to disclose artificial intelligence and earn about 0.33 points less on assets, a gap that is not significant within country-years. The cross-bank association is therefore consistent with stable bank differences rather than returns to disclosure. We recommend that Islamic finance standard setters add structured artificial intelligence disclosure items, that supervisors avoid treating narrative as evidence of capability, and that Shariah supervisory boards bring algorithmic pricing and allocation systems within prior review, so that technology spending in halal finance creates measurable value rather than waste.

Keywords: Artificial intelligence; Islamic banking; Conventional banking; Bank profitability; Textual analysis; Disclosure

1. Introduction

1.1 Research topic and importance

Banks now use artificial intelligence (AI) in credit assessment, fraud detection, customer service and compliance, and their annual reports have changed accordingly: in our corpus the share of reports containing at least one validated AI sentence rose from about one in ten in 2016 to about seven in ten in 2025. A fast-growing literature treats this text as evidence of what banks do with the technology and reports, with notable consistency, that banks disclosing more about AI perform better.[1] The question carries particular weight for Islamic economics. Islamic banks adopt the same technologies under a distinct contractual and governance order, in which interest is prohibited (Surat al-Baqarah, verse 275), new products pass through Shariah supervisory board review, contracts must control uncertainty

(*gharar*), and investment account holders share in the returns on the assets they fund. Developing Shariah-compliant solutions for the digital economy presupposes knowing whether technology disclosure carries information about value creation in these institutions.

1.2 Problem statement

A correlation between technology disclosure and profitability across banks is consistent with two mechanisms. Under the first, adopting AI lowers costs and sharpens risk assessment, and the bank both benefits and reports the fact. Under the second, stable bank characteristics raise both the propensity to write about AI and profitability. Only the first supports the conclusion that investing in AI raises performance, and separating the two requires observing the same bank over time. For Islamic banks the problem is compounded: the only direct evidence on AI text and performance in Islamic banking uses 71 Islamic banks without a conventional comparison group,[2] so it cannot say whether the relationship differs between the two banking models.

1.3 Objectives and research questions

The study has three objectives: to measure AI disclosure in Islamic and conventional banks with a single validated pipeline; to test whether the association between disclosure and profitability changes when stable bank differences are held constant; and to test whether it differs between the two banking models, deriving recommendations for standard setters, supervisors and Shariah supervisory boards. RQ1: Is AI disclosure associated with bank profitability? RQ2: Does the association change under within-bank identification? RQ3: Does it differ between Islamic and conventional banks?

1.4 Scope and methodology

The study covers 290 banks, 104 of them Islamic, in 25 countries over the financial years 2015 to 2025, using English-language annual reports; banks reporting only in Arabic are outside its scope. It follows a quantitative, inductive design. AI sentences are retrieved with a finance-specific lexicon and validated with a transformer classifier whose precision is audited on both bank types. Confidence and tone measures exist only when a report contains AI sentences, so the main analysis conditions on disclosure; volume and scope measures, which are zero for non-disclosing reports, are also analysed on the full panel. Pooled and within-bank estimates are compared with a bank-cluster bootstrap and a within-between model, and nonlinear alternatives are estimated with exact fixed-effects absorption.

1.5 Literature review

AI and bank performance. Baffour Gyau and co-authors find positive effects of AI technology innovation on bank returns across twenty countries.[3] Shiyyab and co-authors report that AI disclosure is associated with better financial performance of Jordanian banks.[4] Related studies link financial technology investment to profitability in European banks,[5] document the determinants of AI adoption in banking services,[6] and connect dynamic capabilities in digital transformation to performance.[7] The proposed mechanisms, cheaper credit assessment, automated compliance and lower servicing costs,[8] operate within banks, yet much of the evidence is identified from differences between banks and so may confound adoption with stable characteristics such as size or management quality.

Textual analysis. Domain-specific dictionaries outperform general lexicons in financial text,[9] report sentiment has been used to predict the performance of Islamic banks,[10] and transformer classifiers now

measure AI discourse in central bank communications[11] and Islamic bank reports.[12] This work shows that report text carries signal; it does not show that the signal in technology disclosure reflects its effect on profitability.

Islamic and conventional banks. The two models differ in business model, efficiency and stability,[13] in risk,[14] and in capital structure.[15] AI applications in Islamic bank accounting have been documented,[16] alongside concerns that opaque algorithms may sit uneasily with Shariah review.[17] No study compares AI disclosure and performance across the two models with a common measure in the same countries and years. This is the gap the study fills.

1.6 Contributions

Relative to the Islamic bank evidence of Ali and Aysan, the study adds a conventional comparison group, bank fixed effects, formal tests of the pooled and within-bank difference, a zero-inclusive panel and six disclosure measures. It makes four contributions: it shows how far the positive association in this literature depends on comparisons between banks; it provides the first direct Islamic and conventional comparison with a common audited pipeline; it separates classifier confidence, tone, volume and scope, which prior composite measures conflate; and it translates the evidence into recommendations for AAOIFI, the IFSB, supervisors and Shariah supervisory boards.

2. Theoretical Framework and Hypotheses

2.1 Economic theories of technology and disclosure

The resource-based view holds that firms earn superior returns from resources that are valuable, rare and hard to imitate;[18] an inimitable AI capability would confer a stable advantage, visible as differences between banks rather than changes within a bank tied to when it discusses AI. Diffusion theory predicts that returns accrue to early adopters and erode as a technology becomes standard.[19] Institutional theory holds that organisations adopt practices for legitimacy as well as efficiency,[20] so disclosure may spread irrespective of capability.

Disclosure theory treats voluntary disclosure as strategic;[21] under a signalling reading only capable firms disclose in detail,[22] whereas under a cheap talk reading claims that outsiders cannot verify convey little.[23]

2.2 Why the Islamic banking model might differ

Three features of Islamic banking bear on how AI is deployed and disclosed. They motivate the comparison; the study does not measure any of them directly.

Ex ante Shariah review. Shariah governance frameworks require the Shariah board to endorse and validate the documentation for new products and services before launch.[24] Algorithm-driven products therefore pass through a review layer that conventional banks do not face, which predicts smaller or later returns to AI.

Control of gharar. Abu Hurayrah reports that the Prophet (peace be upon him) prohibited sales involving gharar,[25] and AAOIFI Shari'ah Standard No. 31 sets out controls on gharar in financial transactions.[26] A model that prices financing or allocates returns through logic counterparties cannot assess introduces the uncertainty these controls address, giving Islamic banks a doctrinal reason to

explain algorithmic systems and making their disclosure closer to a costly signal. The constraint concerns uncertainty, not the digital channel: Shari'ah Standard No. 38 accepts contracts concluded through electronic means subject to its conditions.[27] *Investment account holders.* The IFSB disclosure standard seeks to "facilitate access to relevant, reliable and timely information by market participants generally, and by investment account holders in particular."[28] Because these holders share in asset returns, technology disclosure is addressed to a risk-sharing audience, which raises the cost of unsupported claims.

Recent work proposes a Shariah governance standard specifically for generative AI in Islamic financial institutions.[29] The first feature predicts weaker returns to AI disclosure in Islamic banks and the other two stronger ones. The data contain no Shariah governance variable: the Islamic bank indicator captures every difference between the two models, so the test concerns the banking model as a whole.

2.3 Hypotheses

H1. AI disclosure is positively associated with bank profitability. *H2.* The association is weaker under within-bank identification than under pooled identification. *H3.* The association differs between the Islamic and conventional banking models.

3. Data and Methodology

3.1 Sample and data

The corpus contains 2,681 annual reports of 290 bank entities in 25 countries, 186 conventional and 104 Islamic, for 2015 to 2025, totalling 229.6 million words and 8.66 million sentences. Each entity's classification follows the report metadata, which records the institution's own designation; where a conventional bank and its Islamic window appear as separate entities, each carries its own label. Bank financials come from Fitch Connect. Because entity names differ between reports and the Fitch extract, linkage used exact matching on normalised names, then on names stripped of legal form tokens, then a curated crosswalk; fuzzy matching was rejected after it produced plausible but wrong links, such as Habib Bank Limited to Bank AL Habib Limited. Of 290 entities, 258 were linked (Appendix Table A1).

GDP growth and internet penetration come from the World Development Indicators and regulatory quality from the Worldwide Governance Indicators.[30] Where a year is not yet published, both series are carried forward within country. The analysis sample contains 872 bank-years, of which 144 use a carried-forward value: all 119 observations for 2025 and 25 earlier ones.

3.2 Measuring AI disclosure

Reports are segmented with PySBD, a rule-based sentence boundary detector,[31] after normalising Unicode, repairing line-end hyphenation and handling page breaks. Candidate sentences are retrieved with the FinAI Dictionary of 69 AI terms in seven categories (artificial intelligence, machine learning, deep learning, natural language processing, computer vision, generative AI and explainable AI), matched case-insensitively on complete tokens, yielding 6,586 candidates.[32] Each candidate is then scored by the BERT-based AI classifier of Zafar, Ali and Aysan,[33] with a maximum sequence length of 128 tokens and the decision threshold of P(AI) of at least 0.05 fixed in that model's original

validation. The classifier retains 5,797 sentences (88.0 percent) and rejects 789. The companion BERT sentiment classifier from the same source labels retained sentences positive (60.8 percent), negative (5.7 percent) or neutral (33.5 percent), with the probability of the predicted class.

Because the classifier was not trained on bank annual reports, we audited its precision.

A random sample of 200 retained sentences, stratified by bank type and period (2015 to 2020, 2021 to 2025), was labelled by the authors for whether the matched term refers to AI technology, without reference to classifier scores. Precision is 98.5 percent overall (95 percent interval 95.7 to 99.7), 99 percent for conventional and 98 percent for Islamic banks, and at least 98 percent in every stratum (Appendix Table A5). The three errors are glossary entries or proper names. Recall cannot be audited because rejected sentences are not retained in the corpus files.

Six bank-year measures follow. Two are classifier confidence measures: the *AI BERT score*, the mean P(AI) of the retained sentences, and the *AI sentiment score*, the mean probability of the predicted sentiment class. Because the threshold is 0.05, a bank-year whose few retained sentences are marginal can have a low mean score; the sample minimum is 0.064, and 1.7 percent of retained sentences score below 0.5. Four measures capture tone, volume and scope: *signed sentiment*, the mean of the predicted-class probability multiplied by +1 for positive, -1 for negative and 0 for neutral sentences; *disclosure intensity*, validated AI sentences per thousand report sentences; *category breadth*, the number of the seven categories present; and the *log AI sentence count*, ln(1 + count). The two confidence measures correlate at 0.077.

All measures are standardised within the analysis sample, so coefficients are percentage-point changes per standard deviation.

3.3 Variables

Return on assets (ROA) is the dependent variable, preferred to return on equity (ROE) because ROE is mechanically sensitive to leverage, which differs between the two models;[34] ROE is a robustness check. Both are winsorised at the first and ninety-ninth percentiles.

Controls are asset growth, the impaired loan ratio,[35] GDP growth, internet penetration[36] and regulatory quality.[37] Appendix Table A4 defines every variable.

3.4 Empirical strategy

The pooled model includes country and year effects, which identify the time-invariant Islamic indicator:

$$ROA(i,t) = a + b\,AI(i,t) + c\,ISLAMIC(i) + g\,X(i,t) + country(j) + year(t) + e(i,t)$$

The within-bank model replaces country effects with bank effects, so b is identified only from changes within a bank over time:

$$ROA(i,t) = a(i) + year(t) + b\,AI(i,t) + g\,X(i,t) + e(i,t)$$

Standard errors are clustered by bank.[38] The pooled model is not a pure between-bank estimator: it combines variation within and between banks. H2 is therefore tested in two ways.

First, a bank-cluster bootstrap with 999 draws resamples whole banks and re-estimates both models, giving a confidence interval for the difference in coefficients.[39] Second, a within between model enters

each regressor as its deviation from the bank mean together with the bank mean, with year effects, and tests equality of the two AI slopes.[40] Third, a paired test estimates the difference on the same observations and takes its variance from the bank-level score contributions of both models, so their covariance is retained and a change in two separate p values is not mistaken for a significant change in the coefficient. Because six measures are tested, pooled and difference p values are also adjusted across measures by the Holm procedure. H3 adds AI(i,t) x ISLAMIC(i) to the within-bank model. A specification with country-by-year effects compares banks only within the same country and year.

Nonlinear alternatives are estimated without approximate demeaning. Restricted cubic spline terms are constructed from each raw AI measure and entered in regressions that absorb bank and year effects exactly, and their joint significance is tested. Random forests are evaluated with five-fold cross-validation grouped by bank, so no bank appears in both training and test data; for the within-bank version, each training and test subset is residualised separately on its own bank and year effects by exact iterative absorption. This matters: on the analysis sample, simple one-pass demeaning (subtracting bank and year means and adding the grand mean) gives a coefficient of -0.004 for the AI BERT score, against -0.014 under exact absorption, because the panel is unbalanced.

4. Descriptive Analysis

Table 1 describes the 872 bank-years from 191 banks (127 conventional, 64 Islamic) in 22 countries over 2016 to 2025. Islamic banks earn 0.50 percentage points less on assets ($p < 0.001$) and 1.87 points less on equity ($p = 0.032$). Among disclosing banks, they do not differ from conventional banks in intensity, breadth, confidence or tone, but their reports contain fewer AI sentences (log count 1.40 against 1.56, $p = 0.005$).

Table 1. **Descriptive statistics and differences between conventional and Islamic banks**

Variable	Mean	SD	Min	Max	Conv.	Islamic	Diff.	p
								value
Return on assets								
(%)	1.490	1.435	-7.130	7.593	1.630	1.134	-0.495	<0.001
Return on equity	14.399	11.224	-35.336	53.848	14.924	13.054	-1.870	0.032
(%)								
AI BERT score	0.967	0.122	0.064	1.000	0.970	0.961	-0.009	0.339
AI sentiment								
score	0.894	0.096	0.463	0.993	0.892	0.902	0.010	0.176
Signed AI	0.520	0.404	-0.993	0.993	0.512	0.541	0.029	0.351
sentiment								
AI disclosure								
intensity	1.365	1.431	0.050	10.066	1.391	1.299	-0.092	0.385
Log AI sentence	1.514	0.811	0.693	4.159	1.561	1.395	-0.166	0.005
count								
AI category	1.983	1.029	1.000	6.000	2.014	1.902	-0.112	0.136
breadth								
Asset growth (%)	15.559	17.983	-22.400	105.930	15.601	15.452	-0.149	0.916
Impaired loan	4.770	5.361	0.000	69.122	4.894	4.453	-0.441	0.360

ratio (%)								
GDP growth (%)	3.223	3.469	-9.518	13.826	3.008	3.773	0.765	0.003
Internet								
penetration (%)	75.383	24.431	12.385	100.000	73.775	79.500	5.726	0.002
Regulatory	0.173	0.626	-0.996	1.907	0.118	0.314	0.196	<0.001
quality								

Note: 872 bank-years from 191 banks in 22 countries, 2016 to 2025 (627 conventional, 245 Islamic), conditional on at least one validated AI sentence. Difference is Islamic minus conventional, Welch two-sample t-test. AI measures in raw units.

Figure 1 traces disclosure on the full panel of 2,029 bank-years. The share of reports with at least one validated AI sentence rose from 10.9 to 68.2 percent among conventional banks between 2016 and 2025 and from 8.3 to 77.5 percent among Islamic banks. Conventional banks led in every year except 2022 and 2025. The 2025 Islamic share rests on 40 reports, so the apparent reversal should be read cautiously; conditional on controls and country and year effects, Islamic banks are 8.3 percentage points less likely to disclose AI over the period (p = 0.048).

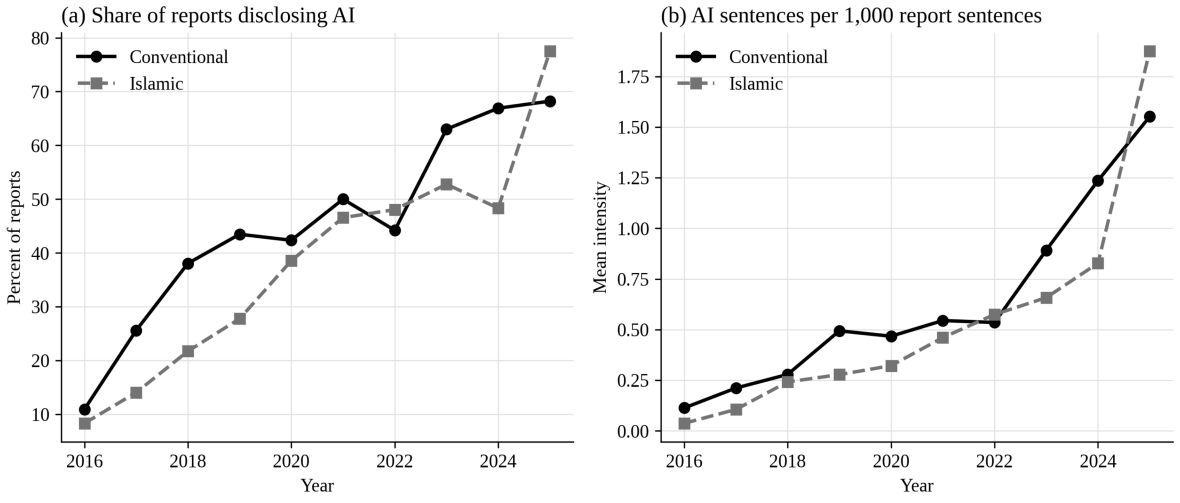

Figure 1. **AI disclosure in bank annual reports, 2016 to 2025**

Note: Full panel of 2,029 bank-years. Panel (a): share of reports with at least one validated AI sentence. Panel (b): validated AI sentences per thousand report sentences. Black solid line:

conventional banks; grey dashed line: Islamic banks. The 2025 Islamic value rests on 40 reports.

Figure 2 shows why the confidence measures behave as they do. Both distributions are concentrated near one: the classifier is confident about most retained sentences, and 98.3 percent of them score above 0.5. The two bank types overlap almost exactly, which is what the precision audit reports in a different form. The measures therefore carry information mainly through the small left tail rather than through wide variation across reports.

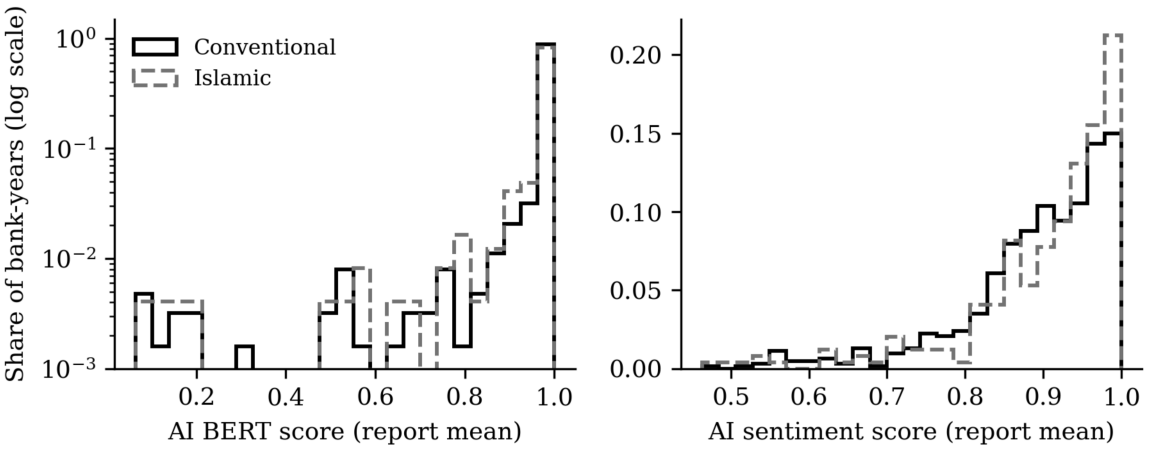

Figure 2. **Distribution of the two confidence measures by bank type**

Note: 872 disclosing bank-years. Report means of the classifier probability and of the predicted sentiment probability. Panel (a) uses a logarithmic vertical scale because most reports sit near one. Black solid line: conventional banks; grey dashed line: Islamic banks.

5. Results and Findings

5.1 AI disclosure and profitability (H1 and H2)

Table 2 reports the two confidence measures. In the pooled model a one standard deviation increase in the AI BERT score is associated with a 0.065 percentage point higher

ROA (standard error 0.031, p = 0.037), about four percent of mean profitability; the sentiment coefficient is similar but not significant (0.071, p = 0.140). Under bank fixed effects the BERT coefficient is -0.014 (standard error 0.021) and the sentiment coefficient -0.015, neither distinguishable from zero.

Whether the two coefficients differ is tested directly in Table 3. For the AI BERT score the bootstrap difference is 0.079 with a 95 percent interval of 0.015 to 0.138 (p = 0.008); the paired test, which is the more conservative of the two, gives the same difference with p = 0.016, so the attenuation is statistically significant on both tests. The within-between model, whose between-bank slope rests on 191 bank means and is imprecise, does not reject equality (p = 0.288). The evidence is therefore consistent with H2 for this measure but not conclusive. Fixed effects remove stable differences between banks, not time-varying confounders or reverse causality, so neither estimate should be read as a causal effect.

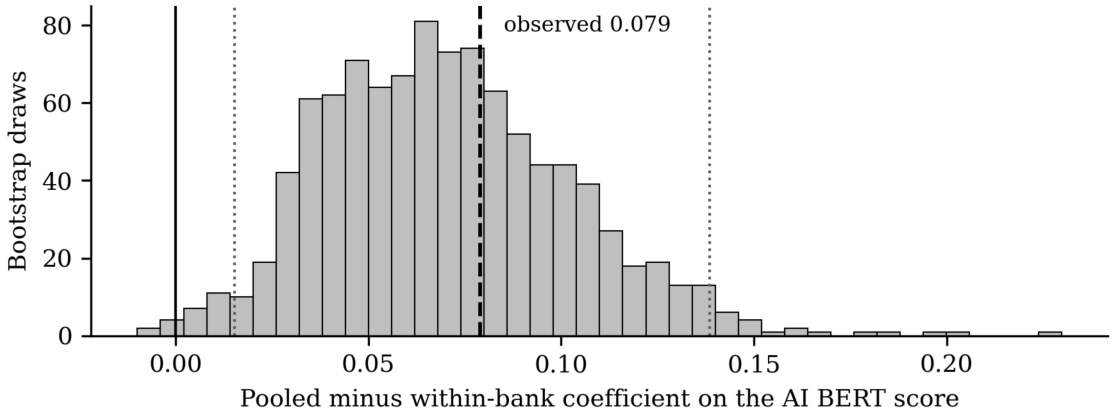

Figure 3. **Bootstrap distribution of the pooled minus within-bank coefficient**

Note: 999 draws resampling whole banks, AI BERT score, return on assets. Dashed line: observed difference of 0.079. Dotted lines: the 2.5th and 97.5th percentiles, 0.015 and 0.138. Solid line: zero.

Table 2. **AI disclosure and return on assets: confidence measures**

	AI BERT score		AI sentiment score	
Variable	(2) Bank (1) Pooled FE	(3) AI x Islamic	(5) Bank (4) Pooled FE	(6) AI x Islamic
AI measure	0.065** -0.014	-0.031	0.071 -0.015	0.008
	(0.031) (0.021)	(0.027)	(0.048) (0.027)	(0.027)
Islamic bank	-0.334** absorbed	absorbed	-0.338** absorbed	absorbed
AI measure x	(0.156)	0.046	(0.158)	-0.087
Islamic		(0.049)		(0.084)
Asset growth	0.013** 0.010**	0.010**	0.014** 0.009**	0.009**
	(0.005) (0.004)	(0.004)	(0.005) (0.004)	(0.004)
Impaired loan	-0.048** -0.111***	-0.111***	-0.047** -0.111***	-0.112***
ratio	(0.024) (0.028)	(0.028)	(0.024) (0.028)	(0.028)
GDP growth	-0.015 -0.003	-0.003	-0.015 -0.003	-0.004
	(0.014) (0.013)	(0.013)	(0.014) (0.013)	(0.013)

	AI BERT score		AI sentiment score	
Variable	(1) Pooled	(2) Bank (3) AI x FE Islamic	(5) Bank (4) Pooled FE	(6) AI x Islamic
Internet	-0.001	-0.008 -0.008	-0.002 -0.007	-0.007
penetration	(0.005)	(0.006) (0.006)	(0.005) (0.006)	(0.006)
Regulatory	-0.275	-0.896* -0.897*	-0.388 -0.877*	-0.881*
quality	(0.609)	(0.535) (0.533)	(0.596) (0.528)	(0.528)
Fixed effects	Country,	Bank, year Bank, year	Country, Bank, year	Bank, year
	year		year	
Observations	872	872 872	872 872	872
R-squared	0.360	0.162 0.163	0.360 0.162	0.164

Note: Dependent variable: return on assets (percent). AI measures standardised. Standard errors clustered by bank in parentheses, with degrees of freedom counting all fixed effects. R-squared is within-bank for fixed effects columns. *** p<0.01, ** p<0.05, * p<0.1.

5.2 Six measures of AI disclosure

Table 3 and Figure 4 extend the comparison to all six measures. The pooled coefficients on the log sentence count (0.134, p = 0.079) and category breadth (0.109, p = 0.054) are positive and marginally significant, and both attenuate under bank fixed effects to 0.014 and 0.025. For these measures, however, neither test of the difference rejects equality (bootstrap p = 0.184 and 0.142, paired p = 0.131 and 0.121), and the within-bank intervals remain wide: for breadth, from -0.059 to 0.109, which does not exclude a meaningful positive association. Intensity and signed sentiment are insignificant in both models. The pattern of attenuation is consistent across measures, but it is statistically established only for the AI BERT score.

Multiplicity matters here: after Holm adjustment across the six measures, no pooled coefficient remains significant (smallest adjusted p = 0.222) and the BERT difference has an adjusted p of 0.095. The single-measure pooled results are therefore exploratory, and the robust finding is the absence of a within-bank association rather than the size of any pooled coefficient.

Table 3. **Six AI disclosure measures: pooled and within-bank estimates and formal tests of H2**

			Difference	Boot.	Paired	Mundla
AI measure	Pooled	Bank FE	[95% CI]	p	p	k p
AI BERT score	0.065**	-0.014	0.079 [0.015,	0.008	0.016	0.288
	(0.031)	(0.021)	0.138]			
AI sentiment	0.071	-0.015	0.085 [-0.007,	0.080	0.084	0.191
score	(0.048)	(0.027)	0.176]			
Signed AI	-0.041	-0.002	-0.039 [-0.125,	0.358	0.342	0.387
sentiment	(0.050)	(0.041)	0.038]			
AI disclosure	0.020	-0.016	0.036 [-0.114,	0.831	0.602	0.824
intensity	(0.083)	(0.051)	0.158]			
Log AI sentence	0.134*	0.014	0.120 [-0.036,	0.184	0.131	0.464
count	(0.076)	(0.057)	0.261]			
AI category	0.109*	0.025	0.083 [-0.037,	0.142	0.121	0.476
breadth	(0.056)	(0.043)	0.177]			

Note: Return on assets, N = 872, full controls, each measure standardised. Difference is pooled minus bank fixed effects, with a percentile interval and two-sided p value from 999 bank cluster bootstrap draws. Paired p uses the analytic variance of the difference, which retains the covariance between the two models. Mundlak p tests equal within-bank and between-bank slopes in a within-between model with year effects. Holm-adjusted values across the six measures appear in Section 5.2. *** p<0.01, ** p<0.05, * p<0.1.

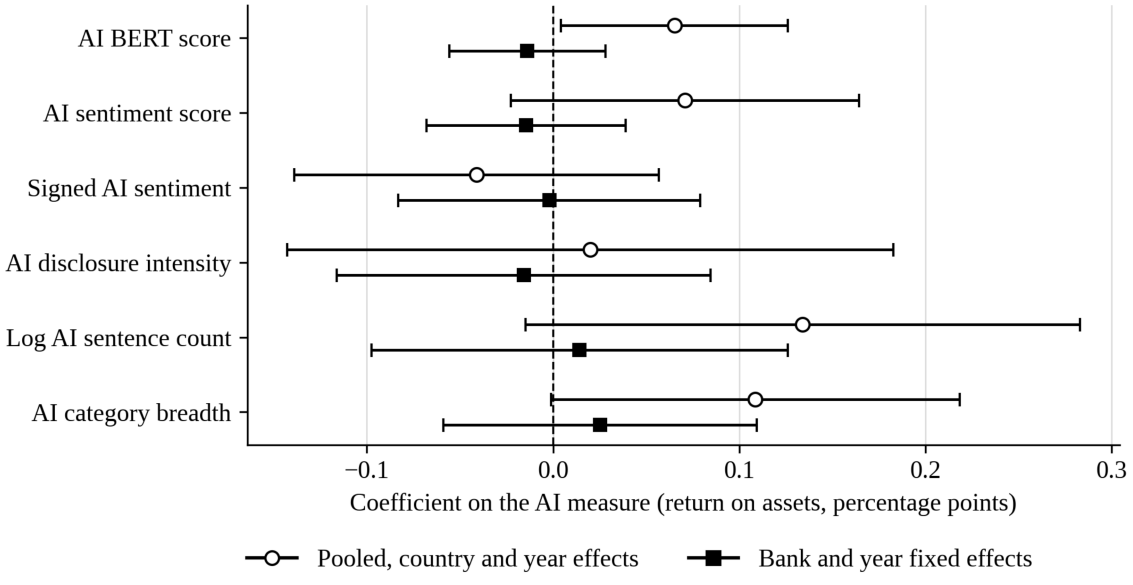

Figure 4. **Coefficient on six AI measures, pooled and within-bank**

Note: Return on assets. Point estimates with 95 percent confidence intervals, standard errors clustered by bank. Values from Table 3.

5.3 Islamic and conventional banks (H3)

With separate country and year effects, Islamic banks earn about a third of a percentage point less on assets (-0.334, p = 0.034), consistent with the efficiency differences documented by Beck and co-authors.[41] Within country-year cells the gap is -0.259 (p = 0.128): 84 of 183 country-years contain both bank types, and the gap partly reflects where Islamic banks operate.

The interaction between AI disclosure and the Islamic indicator is insignificant for all six measures and for ROE: 0.046 (p = 0.345) for the BERT score and -0.087 (p = 0.301) for sentiment. H3 is not supported, but the evidence is a null rather than proof of equality: the 95 percent interval for the BERT interaction, from -0.049 to 0.142, cannot exclude a difference as large as the pooled association.

Three checks address classification. Excluding the 55 observations of Islamic windows that share their conventional parent's Fitch financials leaves the Islamic coefficient at -0.374 (p = 0.033) and the interactions insignificant. Reclassifying three Kuwaiti banks that the metadata label conventional but Fitch classifies as Islamic (16 observations) changes no inference.

Because the Islamic indicator bundles all differences between the models, these results cannot isolate any Shariah governance channel.

5.4 Robustness

Table 4 summarises further tests. With ROE as the dependent variable, the pooled coefficients are positive for the BERT score, breadth and log count (0.465, 1.211 and 1.481, p

< 0.05) and insignificant under fixed effects. Excluding the 144 carried-forward observations, restricting the sample to 67 banks with at least six years of data, and adding country-by-year effects all preserve the pattern: positive pooled estimates and within-bank estimates near zero.

Figure 5 plots the fifteen lagged within-bank coefficients (lags of one to five years for three measures): one is significant at five percent, and it is negative (sentiment at two years, -0.150, p = 0.002). GDP growth does not amplify the association; the one interaction significant at five percent is negative (sentiment, ROA, -0.017, p = 0.042).

Two measurement checks use the sentence records directly. Raising the classifier threshold from 0.05 to 0.5 discards the 99 retained sentences below that probability and drops 15 reports that then hold no AI sentence, leaving 857 bank-years: breadth is 0.127 pooled (p = 0.026) and 0.046 within banks, and the log count 0.140 and 0.017, so the pattern is unchanged.

The confidence measures are not informative at that threshold because their variation is largely removed by construction. Removing the nine sentence records whose stored text is the spreadsheet error string, whose scores and metadata are intact, changes no coefficient by more than 0.003.

Spline terms estimated with exact bank and year effects are jointly insignificant in all eight within-bank tests (p between 0.21 and 0.93). Under bank-grouped cross-validation the random forest explains little out-of-sample variation (R-squared 0.093 in levels, 0.068 within banks), and the AI measures add at most 0.85 percent to prediction error, against 13.97 percent for asset growth; within banks their permutation importance is negative. These models test functional form and do not identify causal effects. Figure 6 shows the same conclusion visually:

after exact absorption of bank effects, year effects and the controls, the linear and cubic fits are almost indistinguishable across the observed range.

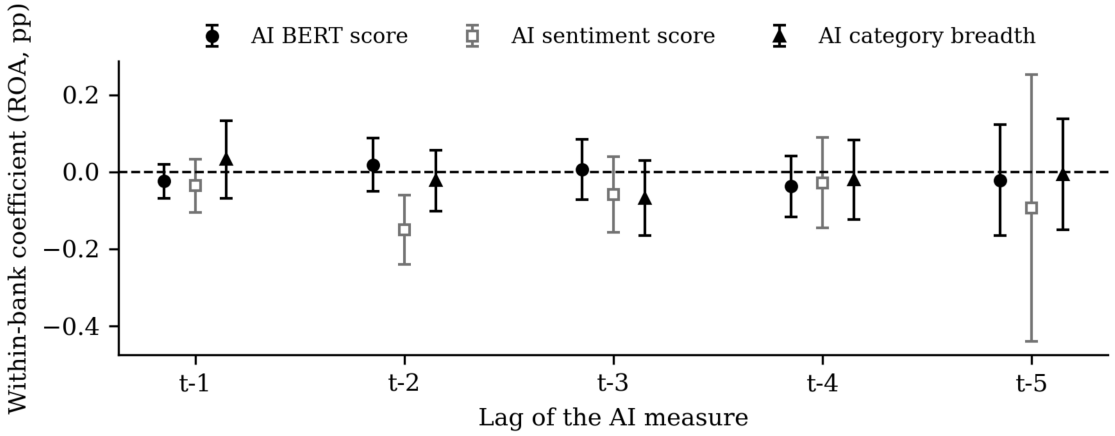

Figure 5. **Within-bank coefficients on lagged AI measures**

Note: Return on assets, analysis sample, bank and year effects, full controls. Each point is a separate regression with the AI measure lagged one to five years, shown with 95 percent confidence intervals from standard errors clustered by bank.

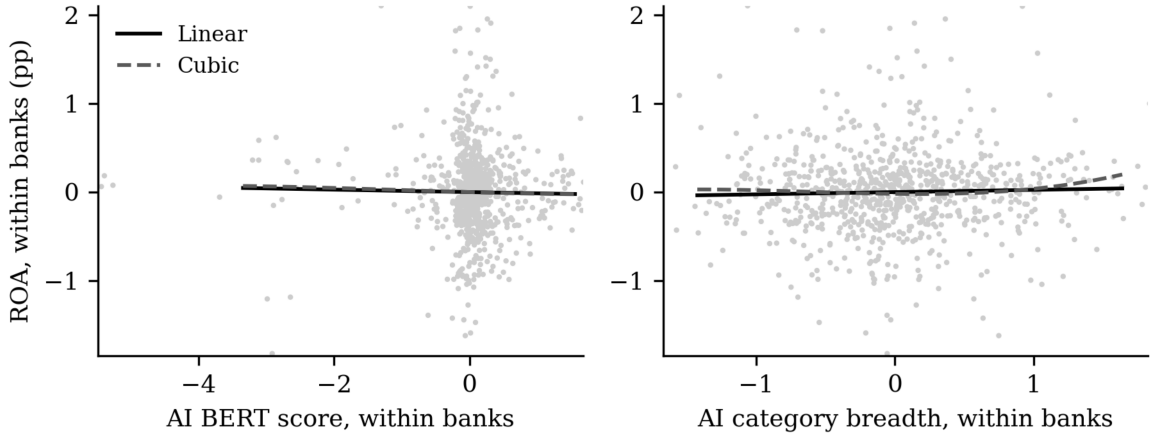

Figure 6. **Linear and cubic fits after exact absorption of bank and year effects**

Note: Return on assets. Both axes are residuals after exact absorption of bank effects, year effects and the controls. Solid line: linear fit. Dashed line: cubic fit. The formal spline tests are reported in Table 4.

Table 4. **Robustness summary**

Test	Specification	AI BERT score	AI category breadth
Return on equity	Pooled	0.465** (0.227)	1.211*** (0.407)
	Bank fixed effects	0.106 (0.229)	0.243 (0.429)
Excluding carried- forward data (N = 728)	Pooled	0.082** (0.035)	0.118* (0.064)

Test	Specification	AI BERT score	AI category breadth
Excluding shared-	Bank fixed effects	-0.018 (0.024)	0.036 (0.043)
financials windows (N =	Pooled	0.069* (0.035)	0.107* (0.059)
817)			
Banks with at least six	Bank fixed effects	-0.012 (0.026)	0.029 (0.047)
years (N = 506)	Pooled	0.104** (0.048)	0.087 (0.068)
	Bank fixed effects	0.022 (0.034)	0.024 (0.044)
Country-by-year effects	Country x year	0.107** (0.043)	0.110* (0.063)
	Bank and country x	-0.017 (0.033)	-0.020 (0.041)
Fitch-based Islamic	year		
label	AI x Islamic, bank FE	0.046 (0.049)	-0.022 (0.119)
Classifier threshold 0.5			
(N = 857)	Pooled	0.158 (0.176)	0.127** (0.057)
Unreadable sentence	Bank fixed effects	-0.041 (0.147)	0.046 (0.044)
text removed	Pooled	0.065** (0.031)	0.109* (0.056)
	Bank fixed effects	-0.014 (0.021)	0.025 (0.043)
Nonlinearity, bank FE	Spline or category F	0.829	0.772
	test p		

Note: Return on assets unless stated; coefficients with standard errors clustered by bank.

Lagged estimates appear in Figure 5. Shared-financials windows are Islamic windows reported under their conventional parent's Fitch entity. Breadth is discrete, so its nonlinearity test uses category indicators. The stricter classifier threshold rebuilds every measure from the sentence records and removes little variation in the BERT score by construction, which widens its standard error. *** p<0.01, ** p<0.05, * p<0.1.

Finally, Table 5 uses the full panel of 2,029 bank-years, where volume and scope are zero for reports without AI sentences; eight reports with fewer than 50 extracted sentences are treated as failed extractions and excluded. Disclosing AI at all is associated with 0.237 percentage points higher ROA in the pooled model (p = 0.024) and -0.063 within banks (p = 0.370); breadth and log count behave the same way, and no Islamic interaction is significant.

The attenuation is therefore not an artefact of conditioning on disclosure.

Table 5. **Zero-inclusive full panel, return on assets**

AI measure	Pooled	Bank FE	AI x Islamic (bank FE)
Discloses AI (0/1)	0.237** (0.104)	-0.063 (0.070)	0.061 (0.133)
AI disclosure intensity	0.042 (0.055)	-0.052 (0.038)	0.047 (0.071)
Log AI sentence count	0.121** (0.059)	-0.052 (0.045)	0.016 (0.071)
AI category breadth	0.116** (0.051)	-0.036 (0.042)	0.013 (0.072)

Note: 2,029 bank-years, 237 banks, 24 countries, including reports without AI sentences (measures equal to zero); eight reports with fewer than 50 extracted sentences excluded as failed extractions. Full controls; continuous measures standardised; standard errors clustered by bank. *** p<0.01, ** p<0.05, * p<0.1.

6. Discussion: Implications for Islamic Economics

First, the evidence does not show that AI is unproductive in Islamic or conventional banks. It shows that the positive association between AI disclosure and profitability rests mainly on comparisons between banks, and that within banks we detect no association under the reported specifications. Annual report disclosure, measured as this literature measures it, is therefore weak evidence of the returns to AI. For a sector committed to avoiding gharar and to informing investment account holders, that weakness is a governance concern as well as a statistical one.

Second, the lower profitability of Islamic banks is not explained by any detectable difference in AI disclosure or in its association with profitability, and it is itself sensitive to comparing banks within the same country and year. Third, nothing in the evidence suggests that operating as an Islamic bank changes the returns to AI disclosure; whether Shariah governance itself helps or hinders requires direct measures of Shariah board characteristics.

Fourth, the practical response is disclosure that can be checked. Table 6 sets out five fields that would let a reader distinguish deployment from aspiration: use and scope, governance, Shariah relevance, measured outcomes and stakeholder safeguards. These fields are proposed by the authors and were not scored in the data, so the estimates say nothing about their effect; they follow from the finding that narrative volume carries little information about performance.

Table 6. **Proposed AI disclosure fields for Islamic banks**

Field	Minimum information	Verification evidence
Use and scope	Business line, purpose and stage of deployment	Named system and reporting period
	Accountable owner, model	Review date and material
Governance	validation and review	limitations
	Contractual functions touched and	Board decision or review
Shariah relevance	scope of Shariah review	reference
Measured outcomes	Baseline, metric, period and comparison method	Cost, service or risk evidence
Stakeholder	Human review, contestability and	Escalation route and material
safeguards	data protection	incidents

Note: Proposed by the authors in the light of the empirical results. These fields were not scored in the data and are not existing mandatory requirements; adoption would require consultation, proportionality and protection of commercial and customer confidentiality.

7. Conclusion and Recommendations

7.1 Main findings

Among AI-disclosing bank-years, positive pooled associations between selected disclosure measures and profitability attenuate after controlling for bank and year fixed effects; the attenuation is statistically significant for the AI BERT score under both a bank-cluster bootstrap and a paired test, though not after Holm adjustment across the six measures. We find no statistically detectable within-bank association, and no difference in slopes between Islamic and conventional banks, under the reported specifications. The pattern holds in the full panel including non-disclosing reports. Islamic banks are less likely to disclose AI and write fewer AI sentences, but disclosing Islamic banks resemble conventional ones in intensity, breadth, confidence and tone.

7.2 Recommendations

1.Because report text is weak evidence of AI capability, AAOIFI and the IFSB should add structured AI disclosure items to their disclosure standards for Islamic banks, covering use cases by business line, model governance and validation, Shariah board review of algorithmic products, and measured outcomes.

2.Supervisors and central banks should not rely on AI narrative in annual reports to assess technological capability, and should collect AI use data through supervisory returns.

3.Because gharar controls apply to opaque pricing and allocation logic, Shariah supervisory boards should bring algorithmic systems that price financing or allocate returns within ex ante product review and report on them in the Shariah board report.

4.Boards of Islamic banks should report quantified outcomes of AI deployment, such as cost, turnaround time or impairment effects, which strengthens accountability to investment account holders.

5.Research on the returns to AI disclosure should address bank heterogeneity and endogeneity credibly, for example with within-bank designs, formal tests of pooled and within estimates, and

adoption measures from outside the annual report.

7.3 Limitations and future research

Disclosure is not adoption, and fixed effects do not remove time-varying confounding or reverse causality; establishing the returns to AI requires external adoption data such as procurement, patents, job postings or supervisory returns. The classifier audit covers precision only, and testing six measures means the individual pooled coefficients should be treated as exploratory. The study has no Shariah governance variable; measures such as Shariah board size, expertise and review practices would allow the channels in Section 2.2 to be tested. The corpus is English-language, which under-represents Islamic banks reporting mainly in Arabic.

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Appendix. Sample, Corpus and Classifier Audit

Table A1. Sample construction

Step	Count	Detail
Annual reports	2,681	290 banks, 25 countries, 2015 to 2025
Candidate AI sentences (FinAI Dictionary)	6,586	69 terms, seven categories
Retained by the BERT classifier	5,797	P(AI) of at least 0.05; 88.0 percent
Banks linked to Fitch Connect	258	32 unlinked branches, non-banks, absorbed banks
Full panel with complete data	2,029	2016 to 2025, 237 banks, 24 countries
Analysis sample (disclosing AI)	872	191 banks, 22 countries
With carried-forward country data	144	119 in 2025, 25 earlier

Note: 2015 reports have no matching bank financial data and enter only the text corpus.

Table A2. Banks in the full panel by country and type

Country	Conventional	Islamic	Country	Conventional	Islamic
Afghanistan	3	1	Nigeria	11	1
Bahrain	4	8	Oman	5	2
Bangladesh	4	7	Pakistan	16	6
Brunei	0	1	Philippines	9	1
Egypt	10	2	Qatar	4	8
Indonesia	4	7	Saudi Arabia	6	4
Iraq	0	2	South Africa	7	1
Jordan	8	1	Sri Lanka	11	1
Kazakhstan	4	1	Switzerland	5	1
Kuwait	8	0	Turkey	19	5
Malaysia	9	13	UAE	6	6
Maldives	1	1	UK	0	3
			Total	154	83

Note: Distinct banks in the full panel of 2,029 bank-years, labelled as in the report metadata.

Table A3. Validated AI sentences by category

		Share			Share
Category	Sentences	(%)	Category	Sentences	(%)
Artificial intelligence	3,929	67.8	Natural language processing	93	1.6
Machine learning	1,552	26.8	Deep learning	59	1.0

Generative AI	531	9.2	Explainable AI	3	0.1
Computer vision	435	7.5			

Note: Shares of the 5,797 retained sentences sum to more than 100 because a sentence can match several categories.

Table A4. Variable definitions and sources

Variable	Definition	Source
ROA, ROE	Return on average assets and equity, percent, winsorised at 1 and 99	Fitch Connect
AI measures	Six bank-year measures from retained AI sentences (Section 3.2), standardised	Annual reports
Islamic bank	One if the report metadata label the entity Islamic	Report metadata
Asset growth	Growth of total assets, percent, winsorised	Fitch Connect
Impaired loan ratio	Impaired loans over gross loans, percent, winsorised	Fitch Connect World Bank
GDP growth	Annual real GDP growth, percent	WDI
Internet penetration	Individuals using the internet, percent of population	World Bank WDI
		World Bank
Regulatory quality	Worldwide Governance Indicators estimate	WGI

Note: Internet penetration and regulatory quality are carried forward within country where not yet published.

Table A5. Precision audit of the AI classifier

			Precision	
Stratum	Sentences	Correct	(%)	95% interval
Conventional, 2015 to 2020	50	49	98.0	89.4 to 99.9
Conventional, 2021 to 2025	50	50	100.0	92.9 to 100.0
Islamic, 2015 to 2020	50	49	98.0	89.4 to 99.9
Islamic, 2021 to 2025	50	49	98.0	89.4 to 99.9
All	200	197	98.5	95.7 to 99.7

Note: Random sample of retained sentences stratified by bank type and period, labelled by the authors for whether the matched term refers to AI technology without reference to classifier scores; exact binomial intervals.

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(O-44) "TOWARDS SUSTAINABLE HALAL TOURISM: INTEGRATING DESTINATION GOVERNANCE, COMMUNITY EMPOWERMENT, AND RESPONSIBLE TOURISM DEVELOPMENT"

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Abstract

Halal tourism is emerging as an important segment of the global tourism industry, driven by the increasing mobility of Muslim travelers and growing demand for destinations that are inclusive, ethical, safe, and sustainable. However, the development of halal tourism should not be understood solely in terms of providing products, facilities, and services that meet the needs of Muslim travelers. The key challenge lies in integrating halal principles with destination governance, local community empowerment, environmental protection, and responsible tourism practices. This paper aims to develop a conceptual framework for sustainable halal tourism by integrating three key dimensions: destination governance, community empowerment, and responsible tourism development. A conceptual approach is employed by examining the interrelationships among the principles of halal tourism, sustainable tourism development, responsible tourism, and collaborative destination governance. The analysis indicates that destination governance serves as an integrative mechanism for aligning the interests of government, tourism businesses, local communities, visitors, and other stakeholders in destination planning, decision-making, resource management, and the equitable distribution of tourism benefits. At the same time, community empowerment constitutes a fundamental pillar for ensuring that local communities are not merely beneficiaries of tourism development, but also key actors in value creation, destination management, and the conservation of local resources. The principles of responsible tourism further strengthen the ethical dimension of tourism development by promoting the balanced management of its social, economic, cultural, and environmental impacts. The proposed framework positions halal tourism not merely as a tourism approach designed to meet the needs of Muslim travelers, but as a destination development model grounded in sustainability, equity, inclusivity, and shared responsibility. This framework is expected to provide a conceptual foundation for developing competitive halal destinations while generating tangible benefits for local communities and safeguarding the long-term sustainability of destination resources.

Keywords: halal tourism; destination governance; community empowerment; responsible tourism; sustainable tourism

INTRODUCTION

Halal tourism is developing in line with the increasing needs of Muslim travelers for products, facilities, and services that comply with Islamic principles (Battour & Ismail, 2016; Henderson, 2016). However, its development is not solely focused on meeting the needs of tourists; it also needs to

integrate the principles of sustainable tourism, which encompass economic, socio-cultural, and environmental balance (WCED, 1987; Bramwell & Lane, 1993), Li, X. (2021), Lima, J., Serra, J., Borges, M. D. R., & Marujo, N. (2024). The main challenge is to ensure that collaborative destination governance, local community empowerment, equitable benefit distribution, and environmental protection are integrated. Therefore, this research aims to develop a conceptual framework for sustainable halal tourism through the integration of destination governance, community empowerment, and responsible tourism development. This conceptual approach is expected to explain the interdimensional relationships and integration mechanisms in realizing inclusive, ethical, and sustainable halal destinations (Goodwin, 2011), Martins, C. A., Carneiro, M. J. A., & Pacheco, O. R. (2021). Based on the above literature, the development of sustainable halal tourism requires a conceptual framework that integrates destination governance, community empowerment, and responsible tourism development.

These three dimensions have complementary functions. Destination governance provides mechanisms for coordination, collaboration, and decision-making; community empowerment ensures substantive participation and a more equitable distribution of benefits; while responsible tourism translates policies and agreements into practices that protect the environment, respect culture, and enhance community welfare. The integration of the three is aimed at realizing destinations that adhere to halal principles while being sustainable in economic, socio-cultural, and ecological aspects. Therefore, this research develops a conceptual framework that explains the interdimensional relationships and their integration mechanisms in the development of sustainable halal tourism.

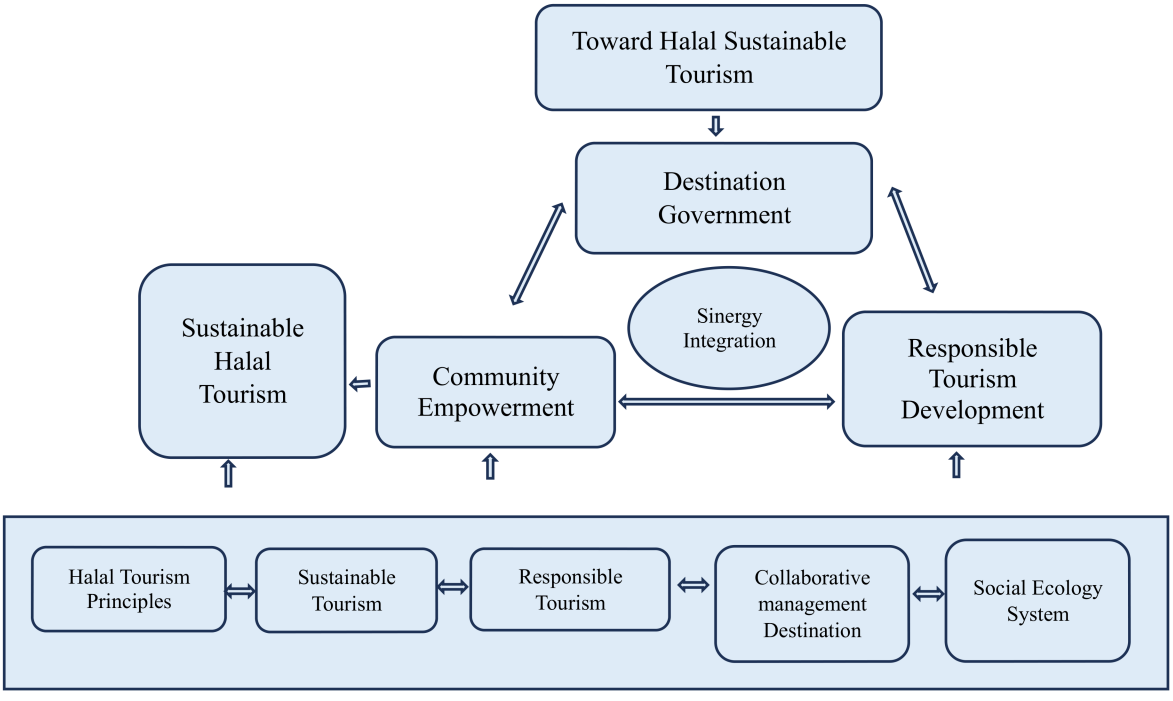

Figure 1: Halal Sustainable Tourism Conceptual Framework

This conceptual framework positions the principles of halal and Islamic ethics as the normative orientation, destination management and community empowerment as the institutional-participatory dimension, and responsible tourism as the operational dimension. The relationships between these

dimensions are complementary and adaptive. Governance provides a space for shared decision-making, while empowerment strengthens the community's capacity and position in that process. The resulting agreements are then implemented through responsible tourism practices and evaluated based on their impact. Monitoring results serve as feedback for policy improvements and the strengthening of participation. Thus, sustainable halal tourism is understood not merely as the fulfilment of halal service standards, but as the result of the integration of values, institutions, participation, and actions that yield economic benefits, social justice, and environmental and cultural sustainability.

The growth of halal tourism reflects the increasing demand among Muslim travellers for services that align with Islamic principles (Battour & Ismail, 2016; Henderson, 2016). Development efforts need to shift from a focus on meeting consumer needs toward a destination development approach that integrates ethics, community well-being, cultural preservation, and environmental sustainability. From a sustainable development perspective, meeting the needs of the present generation must not compromise the ability of future generations to meet their own needs (WCED, 1987). The challenge lies in translating this principle into concrete tourism governance and practices (Bramwell & Lane, 1993; Sharpley, 2000). Therefore, sustainable halal tourism must be developed through the integration of collaborative destination management, the empowerment of local communities, and responsible tourism practices. This integration serves as the foundation for ensuring that adherence to halal principles goes hand in hand with the equitable distribution of benefits, community participation, and the socio-ecological sustainability of the destination.

Local communities are key actors in destination sustainability because they play a role in providing tourism services, preserving culture, and protecting natural resources. Scheyvens (1999) asserts that community empowerment encompasses economic, psychological, social, and political dimensions, while Tosun (2000) identifies barriers to participation resulting from resource constraints and power imbalances. In the context of sustainable halal tourism, empowerment must be realized through business capacity building, access to economic opportunities, institutional strengthening, and substantive community involvement in decision-making. The community-based tourism approach emphasizes the importance of control and tangible benefits for local communities (Murphy, 1985; Goodwin & Santilli, 2009). Thus, community empowerment is not only a goal of tourism development but also a prerequisite for inclusive, equitable, and responsible destination governance.

Responsible tourism emphasizes concrete actions to enhance the benefits of tourism while minimizing negative impacts on the environment, communities, and culture (Goodwin, 2011). These principles include environmental protection, social justice, cultural preservation, enhancing local economic benefits, and community involvement in decision-making (Cape Town Declaration, 2002). In the context of sustainable halal tourism, these principles align with Islamic values such as trustworthiness, justice, the public good, and responsibility. However, compliance with halal standards does not automatically guarantee sustainability; therefore, it must be supported by indicators of social, economic, cultural, and environmental impacts. Within the conceptual framework of this study, responsible tourism serves to translate governance policies and community participation into tangible practices that are measured, evaluated, and continuously improved.

A fundamental challenge in the development of halal tourism is the lack of integration between adherence to halal principles and the goals of sustainable tourism development. The development of halal tourism must not only focus on providing Muslim-friendly products and services but must also

ensure collaborative destination governance, community empowerment, equitable distribution of economic benefits, cultural preservation, and environmental sustainability. Although these three main dimensions have been discussed in tourism literature, a conceptual framework is still needed to explain the interrelationships and mechanisms of interaction among destination governance, community empowerment, and responsible tourism development. Therefore, this study aims to develop an integrative conceptual framework that explains the contributions and relationships of these three dimensions in realizing inclusive, ethical, and sustainable halal tourism, with the latest findings focusing on conceptual integration and an explanation of the mechanisms underlying these relationships— rather than merely combining three theories: institutional integration—specifically, destination governance—links halal policies with sustainability goals through coordination, participation, and accountability; mechanisms for empowering community capacity, authority, and participation influence the quality of decisions and the distribution of tourism benefits; and agreements on governance and community capacity are manifested in practices that are responsible toward the economy, socio-culture, and environment.

The primary focus of this study is to answer how these three dimensions work in an integrated way to realize sustainable halal tourism. This formulation is most consistent with the conceptual approach and can serve as the basis for developing a conceptual framework, theoretical propositions, and an empirical testing agenda in the next phase of the research. Based on the background described above, the following questions arise: How can the principles of halal tourism be integrated with the principles of sustainable tourism development? How do destination governance, community empowerment, and responsible tourism development interact to support the sustainability of halal destinations? How can an integrative conceptual framework be formulated to explain the mechanisms for achieving sustainable halal tourism?

RESEARCH APPROACH

This study employs a qualitative-conceptual approach through an integrative literature review to develop a conceptual framework for sustainable halal tourism. The study population includes scientific publications and academic documents that discuss halal tourism, sustainable tourism development, destination management, community empowerment, and responsible tourism. The units of analysis consist of publications containing concepts, theories, findings, or mechanisms relevant to the integration of these five fields. The sample was selected using criteria-based purposive sampling, taking into account the relevance of the content, the credibility of the sources, the clarity of the theoretical foundation, and the contribution to the research questions.

Data collection was conducted through literature searches in scientific databases, such as Scopus, Web of Science, and Google Scholar, as well as by reviewing relevant academic books and policy documents. Publication selection was carried out by examining titles, abstracts, and full texts based on established inclusion and exclusion criteria. Data were extracted into a matrix covering publication identifiers, theoretical framework, conceptual dimensions, actors, governance mechanisms, community participation, impact management, and implications for destination sustainability.

The analysis was conducted in three main stages. First, a thematic analysis to identify and categorize key concepts, principles, and mechanisms. Second, a comparative analysis to examine similarities, differences, complementary relationships, and gaps among the five fields of study. Third, a conceptual

synthesis to integrate destination governance, community empowerment, and responsible tourism within the framework of sustainable halal tourism. The relationships between these dimensions were examined using an integration matrix that documents the supporting literature and the underlying theoretical mechanisms.

The resulting framework is evaluated based on internal coherence, theoretical consistency, comprehensiveness of integration, and its potential for application in destination planning and management. Transparency is maintained through documentation of the search strategy, selection criteria, extraction matrix, and coding process. Through these procedures, the study is expected to produce a conceptual framework with a traceable literature base that explains the mechanisms for integrating halal values, governance, community empowerment, and responsible tourism practices to support destination sustainability.

Research Population, Unit of Analysis, and Sampling

The research population consists of all scientific publications and academic documents relevant to five fields of study: 1) Halal tourism, 2) Sustainable tourism development, 3) Destination governance, 4) Community empowerment, and 5) Responsible tourism. This population includes journal articles, review articles, academic books, book chapters, and policy documents or guidelines from credible institutions. Literature on collaborative governance, community-based tourism, Islamic ethics, and destination impact management may be used as supporting sources.

Unit of Analysis

The unit of analysis is a publication or document containing concepts, theories, findings, or mechanisms relevant to the relationship between halal tourism and destination sustainability. From each publication, the information extracted includes: Key concepts and definitions; theories or analytical frameworks used; dimensions, indicators, and principles examined; the roles of the government, businesses, the community, tourists, and other stakeholders; mechanisms for participation, coordination, decision-making, and benefit-sharing; management of economic, social, cultural, and environmental impacts; research gaps; and implications for the development of sustainable halal tourism.

Sampling Techniques and Criteria

This study employed criteria-based purposive sampling, which involves intentionally selecting publications based on their relevance and contribution to the research objectives. Since this study integrates several disciplines, this approach was supplemented with citation tracking (both backward and forward).

Table 1. Research Sampling Technique Criteria

Criteria	Required Terms
Substantive Relevance	Directly addresses at least one major field or the relationships among several such fields.
Source Type	Scientific journal articles, review articles, academic books, and credible policy documents.
Time Frame	Publications from 2000–2026; classic literature published before 2000 may still be included if it serves as a primary theoretical foundation.
Language	Indonesian or English.

Access and Completeness	Include comprehensive bibliographic information and sufficient text for analysis.
Exclusions	Duplicate publications, unverifiable sources, writings lacking conceptual relevance, and promotional material without an analytical basis.

Determining Sample Size and Procedures for Data Collection and Extraction

In an integrative literature review, the sample size does not need to be determined using a survey formula such as Slovin's, since there is no statistically defined population of respondents. The number of publications is determined based on search results, compliance with criteria, source quality, and adequacy of conceptual coverage. Researchers may target approximately 60–100 publications for in-depth review, but this figure is only a planning target, not a methodological requirement. The final number must be reported based on the actual selection results. The selection process can be documented through a research flowchart that adopts systematic search and screening procedures.

The stages include identification, removal of duplicates, screening of titles and abstracts, examination of full texts, and determination of which publications will be included in the final analysis. The literature search is conducted through databases such as Scopus, Web of Science, and Google Scholar, with additional searches of academic books as well as official documents from tourism agencies and international organizations.

Table 2. Matrix for Determining Sample Size and Procedures for Data Collection and Extraction

Data Element	Information Recorded
Source Identity	Author, year, title, journal, or publisher
Focus Field	Halal, sustainability, governance, empowerment, or responsibility
Theoretical Framework	Key theories and concepts
Mechanism	Processes linking concepts and outcomes
Actor	Government, community, businesses, tourists, and supporting institutions
Result or Implication	Intended impacts and indicators used
Gap	Limitations or unexplained conceptual relationships
Synthesis Relevance	The publication's contribution to the developed framework

This matrix serves as the basis for consistently comparing the literature, rather than merely summarizing the content of individual publications.

Analysis of Inter-dimensional Relations

This stage constitutes the core of the study's conceptual contribution. Inter-dimensional relations are analysed by distinguishing three types of relationships:

- Complementary relations: one dimension provides a function needed by another dimension.
- Mediation or linking mechanism: one dimension explains how a principle or policy is translated into outcomes.
- Feedback: monitoring and evaluation results are used to improve decision-making, participation, and management practices.

Table 3. The Following Relations Matrix Can Be Used in The Synthesis Process

Relations	Analytical Questions	Evidence Needed Literature
Governance of empowerment	Does governance provide communities with access to decision-making and resources?	Bramwell & Lane, (1993); Sharpley, (2000). Richards, G. (2016), Sujood, Ali, R., Irfan, S., & Hamid, S. (2024), Scheyvens, (1999); Tosun, (2000), Berbel-Pineda, J. M. (2019), Biddle, B. J. (1979b)., Blakey, C. (2012), Bukharov, I., & Berezka, S. (2018), Berbel-Pineda, J. M. (2019).
Responsible tourism empowerment	Do community capacity and control support responsible practices?	Wondirad, A., & Verheye, G. (2023), Young, K. E. (2014), Villagómez-Buele, C. (2020), Vukolic, D. (2022), Murphy, (1985), Goodwin & Santilli, (2009), Richards, G. (2016), Sari, P. A., Turgarini, D., & Handyastuti, I. (2019)., Sujood, Ali, R., Irfan, S., & Hamid, S. (2024), Battour & Ismail, 2016; WCED, 1987, Cabral, Ó., Lavrador, L., Orduna, P., & Moreira, R. 2024, Suliyati, T. T. (2017).
Responsible tourism governance	How are policies and standards implemented?	Battour dan Ismail (2016), Henderson (2016), WCED (1987), Bramwell dan Lane (1993), serta Goodwin (2011), López-Guzmán, T. (2017). Mandić, A., Petrić, L., & Pivčević, S. (2025). Nasirpouri Shadbad, F., & Biros, D. (2021), Rašan, D. (2024), Ansell, C., & Gash, A. (2008). Alonso, A. D., Kok, S., & O'Brien, S. (2018b). Aydın, A. (2020a), Blakey, C. (2012).
Responsible and sustainable practices	How do these actions generate benefits or mitigate impacts?	WCED, (1987), Bramwell & Lane, (1993), Li, X. (2021), Lima, J., Serra, J., Borges, M. D. R., & Marujo, N. (2024). Goodwin, (2011), Martins, C. A., Carneiro, M. J. A., & Pacheco, O. R. (2021), Battour, M., & Ismail, M. N. (2016), Lebrun, A.-M., & Bouchet, P. (2024), López-Guzmán, T. (2017), Goodwin, (2011).
Evaluation of governance and empowerment	How are monitoring results used to drive improvements?	Leong, Q. L. (2017), Mandić, A., Petrić, L., & Pivčević, S. (2025), Mudana, I. G. (2024), Ningsih, C., & Turgarini, D. (2020). Belly, T., Hanafiah, M. H., Awang Ali, Q. S., & Zahari, M. S. M. (2024), Leng, K. S., & Badarulzaman, N. (2014), Martins, C. A., Carneiro, M. J. A., & Pacheco, O. R. (2021). Da Mota, C. V., Rodrigues, R. I., Palrão, T., & Madeira, A. (2024), Leng, K. S., & Badarulzaman, N. (2014).

The orientation of these correlations is an initial proposition that requires examination against the literature. Correlations should not be considered causally proven simply because some publications suggest a link.

Conceptual Synthesis

The results of the thematic and comparative analyses were further integrated into a conceptual framework through the following steps: 1) Establishing the principles of halal and Islamic ethics as a normative orientation. 2) Formulating destination governance and community empowerment as institutional and participatory dimensions; 3) Positioning responsible tourism as an operational mechanism to implement decisions and manage impacts; 4) Formulating the intended outcomes, namely economic, sociocultural, and environmental sustainability; 5) Developing monitoring and feedback mechanisms to support continuous improvement. The framework was then cross-referenced with the initial literature to ensure that every relationship had a theoretical basis; no gaps were found. A synthesis of the five areas of study on the concept of halal tourism was formulated.

H = the concept of halal tourism.

S = the concept of sustainable tourism development.

G = the concept of destination management.

E = the concept of community empowerment.

R = the concept of responsible tourism.

Thus, the conceptual synthesis can be formulated as follows:

$$K = f(H, S, G, E, R)$$

where K represents the conceptual framework for sustainable halal tourism. This formulation indicates that the framework is not derived from a single theory but from the integration of the five fields of study. More substantively, the proposed framework can be stated as:

$$K = H + S + I(G, E, R)$$

where I (G, E, R) represents the mechanism for integrating governance, community empowerment, and responsible tourism. The plus sign here symbolizes conceptual synthesis, not mathematical addition.

The conceptual framework should demonstrate that the three main dimensions are not independent components but are interconnected through institutional mechanisms, capacity building, operational implementation, and adaptive feedback. The proposed integrative conceptual framework for sustainable halal tourism development is presented in Figure 2, which illustrates the conceptual synthesis developed in this study.

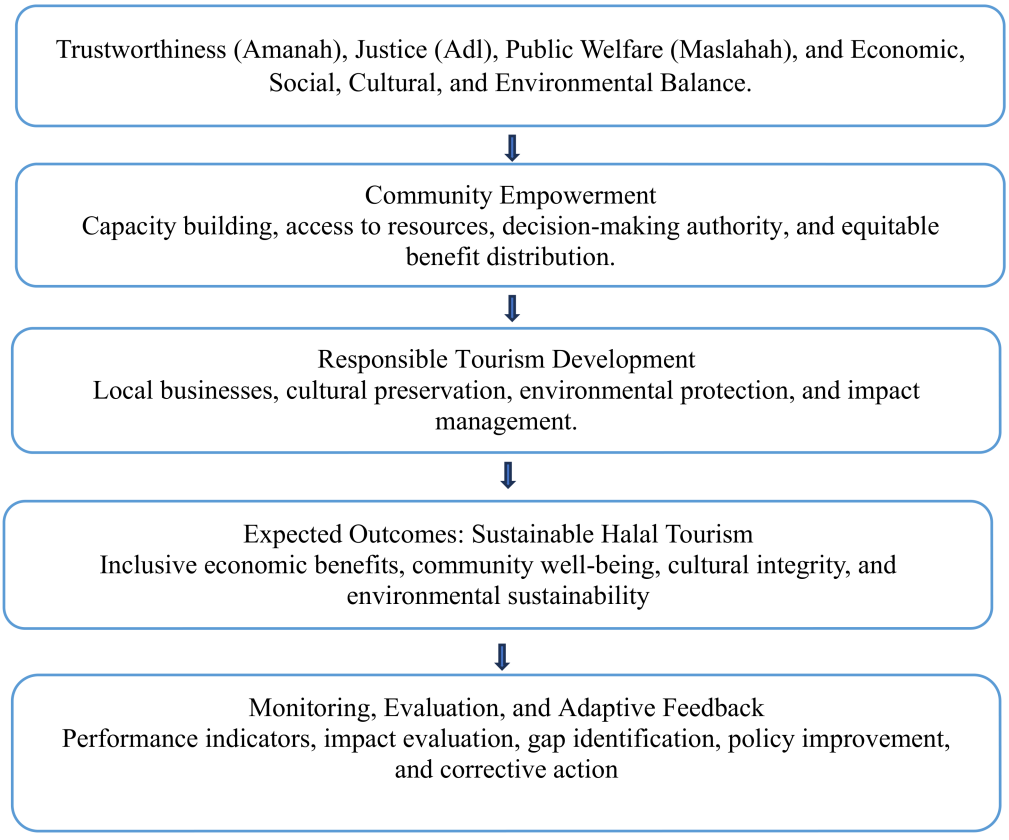

Figure 2. Integrative Conceptual Framework for Sustainable Halal Tourism Development. The diagram presents the proposed conceptual synthesis.

Analysis and Discussion

1. **Integrating the Principles of Halal Tourism with Sustainable Tourism Development**

Halal tourism is fundamentally oriented toward providing products, facilities, and services that comply

with Islamic principles. However, compliance with halal principles does not automatically guarantee the sustainability of a destination. Destinations that provide halal food, places of worship, and Muslim-friendly services must still prioritize the well-being of local communities, cultural preservation, equitable distribution of economic benefits, and environmental protection. From the perspective of sustainable development, as introduced by the WCED (1987), development must meet the needs of the present without compromising the ability of future generations to meet their own needs. This principle broadens the focus of halal tourism from merely meeting the needs of tourists to the development of destinations that are economically, socio-culturally, and ecologically responsible. The integration of these two concepts can be explained through three mechanisms.

1) **Integration of values and ethics**. Halal principles and Islamic values—such as trustworthiness, justice, responsibility, and the common good—serve as the normative framework for destination management.

2) **Institutional and social integration.** These principles are implemented through policies, stakeholder coordination, community participation, and the equitable distribution of tourism benefits.

3) **Operational and ecological integration.** These values and policies are put into practice through measures that protect the environment, respect local culture, improve community well-being, and mitigate the impacts of tourism.

The integration of halal tourism and sustainable development is not merely the addition of environmental and social indicators to halal standards. Rather, this integration represents a broadening of the development orientation—from meeting consumer needs toward ethical, inclusive, and sustainable destination governance. Theoretical implications: Sustainable halal tourism can be understood as a destination development approach that links normative Islamic principles with sustainability goals through institutional mechanisms, participation, and responsible actions. Relevant literature includes Battour and Ismail (2016), Henderson (2016), WCED (1987), Bramwell and Lane (1993), as well as Goodwin (2011) and López-Guzmán, T. (2017). Mandić, A., Petrić, L., & Pivčević, S. (2025). As cited in the research manuscript. The results of implementation then serve as the basis for subsequent evaluation and improvement of governance. Based on the conceptual synthesis, the integration of halal tourism principles and sustainable tourism development is formulated as:

$K_1 = \Phi_1(H, S)$

This formulation indicates that sustainable halal tourism is not only oriented toward meeting the needs of Muslim tourists but also integrates the values of trustworthiness, justice, and the common good with economic, sociocultural, and environmental sustainability. Halal principles serve as a normative framework, while sustainable development provides a direction for achieving long-term benefits for communities and destinations. Thus, the integration of these two expands the concept of halal tourism from merely meeting service standards toward the development of ethical, inclusive, and sustainable destinations (Battour & Ismail, 2016; Henderson, 2016; WCED, 1987), Nasirpouri Shadbad, F., & Biros, D. (2021), Rašan, D. (2024).

2. **How do destination governance, community empowerment, and responsible tourism development interact to support the sustainability of halal destinations?**

This analysis and discussion examine the interactions among destination governance, community empowerment, and responsible tourism development in supporting the sustainability of halal destinations. These three dimensions are understood as complementary components: governance provides policy direction and coordination; community empowerment strengthens participation and the equitable distribution of benefits; and responsible tourism translates both into practices oriented toward economic, sociocultural, and environmental balance.

Table 4. Mechanisms of Inter-Dimensional Interactions in Sustainable Halal Tourism

No	Mechanisms of Inter-Dimensional Interactions	Conceptual Synthesis of Governance, Community Empowerment, and Responsible Tourism
1	**Destination governance as an institutional mechanism**	Serves to link halal tourism policies with sustainable development goals. The government, businesses, the community, and other stakeholders require mechanisms for coordination, role allocation, decision-making, and accountability. Without collaborative governance, halal policies, community empowerment, and environmental protection risk operating in isolation.
2	**Community empowerment as a mechanism for capacity building and benefit distribution**	Mechanisms for capacity building and benefit distribution. Community empowerment cannot be measured solely by participation in tourism activities. Empowerment encompasses the community's ability to influence decisions, access resources, develop businesses, and obtain fair economic benefits. Empowerment serves as the link between open governance and responsible tourism practices. Communities with greater capacity, access to information, and authority have the potential to play a more substantive role in destination management.
	Responsible tourism as an operational mechanism	Responsible tourism translates institutional decisions and community participation into concrete actions. Its implementation includes enhancing local economic benefits, respecting culture, protecting the environment, and managing the impacts of tourism.
	Monitoring and feedback as an adaptive mechanism	Sustainability does not end once policies are implemented. Monitoring results must be used to evaluate achievements, identify disparities in benefits, measure environmental impacts, and refine policies.

Based on Table 4 above, Scheyvens (1999) explains community empowerment through four dimensions—economic, psychological, social, and political—which reflect improvements in well-being, collective capacity, and community control over tourism development. Tosun (2000) emphasizes that community participation is often hindered by structural, operational, and cultural factors that limit involvement in decision-making. Meanwhile, Goodwin (2011) emphasizes the importance of responsible tourism to maximize economic, social, and environmental benefits while minimizing negative impacts, Richards, G. (2016), Sari, P. A., Turgarini, D., & Handyastuti, I. (2019)., Sujood, Ali, R., Irfan, S., & Hamid, S. (2024).

These three perspectives complement one another as the foundation for the development of sustainable halal tourism through inclusive governance, community empowerment, and responsible tourism practices. The relationships among these dimensions are dynamic and adaptive. In summary, governance provides structure and rules; empowerment strengthens the capacity and position of communities; and responsible tourism translates decisions into practice. The results of implementation then serve as the basis for evaluating and improving governance in the future. The relationships among these three dimensions are formulated as follows:

$$K_2 = I\ (G, E, R)$$

This integration occurs through three mechanisms. First, destination governance (G) provides coordination, policy, and collaborative decision-making. Second, community empowerment (E) strengthens capacity, substantive participation, and access to economic benefits. Third, responsible tourism (R) translates these policies and participation into practices that protect the environment, respect culture, and improve community well-being. These mechanisms demonstrate that the three dimensions are complementary, not independent of one another. This line of thinking aligns with Scheyvens (1999), Tosun (2000), and Goodwin (2011). However, the strength of these relationships must be established based on the results of a literature review, rather than assumed to be causally proven.

Theoretically, destination governance provides the institutional structure necessary to facilitate stakeholder participation and coordination. Community empowerment strengthens community capacity and decision-making authority, enabling local communities to participate in decision-making processes and obtain equitable benefits. Responsible tourism subsequently translates institutional agreements and community capacities into management practices that address the economic, sociocultural, and environmental dimensions of sustainability. Monitoring and adaptive feedback complement these relationships by evaluating outcomes and facilitating evidence-based policy adjustments, as presented in Table 5.

Table 5. Conceptual Synthesis of the Mechanisms of Interaction among Dimensions

Dimensi	Mekanisme utama	Kontribusi terhadap keberlanjutan
Destination Governance	Institutional coordination, policies, and accountability	Aligning halal principles with sustainable development objectives.
Community Empowerment	Strengthening community self-reliance and socioeconomic justice	Capacity building, access to resources, decision-making authority, and benefit distribution.
Responsible Tourism	Implementing ethical and environmentally conscious management practices	Translating policies and participation into concrete actions.
Monitoring and Adaptive Feedback	Evaluation of indicators, impacts, and follow-up actions on recommendation	Enabling policy adaptation and continuous improvement

The main conceptual contribution of this framework lies in integrating three substantive dimensions—destination governance, community empowerment, and responsible tourism—with adaptive monitoring as a cross-cutting mechanism. Halal principles provide the ethical foundation guiding these processes, while sustainable development serves as the intended outcome. The Sesaot Tourism Village in West Lombok Regency, West Nusa Tenggara, Indonesia, provides a conceptual example for illustrating the integration of halal tourism and nature-based tourism. This example demonstrates how the framework can be applied to a destination that relies on natural resources and community involvement. The following scenario illustrates its potential application within the framework of Sustainable Tourism Observatories (STOs), drawing on Maturbongs (2020).

a) Destination governance: The village government, tourism managers, tourism awareness groups (kelompok sadar wisata), local businesses, and community members establish agreements on service standards, role allocation, environmental protection, and relevant halal service principles.

b) Community empowerment: Community members receive training in business management, food hygiene and safety, family-friendly tourism services, and local product marketing. They are also provided with opportunities to participate in decision-making and benefit-sharing processes.

c) Responsible tourism: Tourism managers develop local products, maintain the cleanliness of rivers and forest areas, manage waste, respect local cultural values, and mitigate the impacts of tourist visits.

d) Monitoring and adaptive feedback: Stakeholders monitor indicators such as the proportion of local workers, the economic benefits received by the community, visitor satisfaction, the volume of waste managed, and environmental conditions. The findings are then used to improve policies and management practices.

This example demonstrates that the halal character of a destination should not be understood solely in terms of providing facilities or services that meet Muslim tourists' needs. A more integrative approach embeds halal principles within ethical governance, community empowerment, environmental responsibility, and equitable benefit distribution.

Development of an Integrative Conceptual Framework and Theoretical Contributions

The analysis at this stage synthesizes the findings from the two previous discussions. The result should not merely be a combination of the three conceptual boxes, but also demonstrate functional relationships, integration processes, and intended outcomes. Three integration mechanisms can be identified: 1) Institutional integration: Destination governance links halal policies with sustainability goals through coordination, collaboration, delegation of authority, and accountability; 2) Participatory integration: Community empowerment enhances capacity, access to resources, and community influence over decisions as well as the distribution of tourism benefits; 3) Adaptive-operational integration: Responsible tourism implements decisions in practice, while monitoring and evaluation provide feedback for continuous improvement.

Based on this synthesis, the proposed conceptual framework explains that sustainable halal tourism is the result of the interaction between value orientations, institutional mechanisms, participatory capacity, and responsible actions. The success of this integration is assessed not only by the availability of Muslim-friendly facilities but also by local economic benefits, social justice, cultural preservation, and environmental quality, Leong, Q. L. (2017), Mandić, A., Petrić, L., & Pivčević, S. (2025), Mudana, I. G. (2024), Ningsih, C., & Turgarini, D. (2020).

The theoretical contribution that can be proposed is the development of an explanation of the mechanisms of inter-dimensional integration, rather than the automatic creation of a new theory. This framework integrates institutional functions, community participation, accountability, and adaptive feedback into a single explanatory model of sustainable halal tourism. The framework can then be used as a basis for formulating theoretical propositions, operational indicators, and empirical research on specific destinations. The theoretical propositions that can be derived are those derived from the relationships between concepts. Belly, T., Hanafiah, M. H., Awang Ali, Q. S., & Zahari, M. S. M. (2024), Leng, K. S., & Badarulzaman, N. (2014), Martins, C. A., Carneiro, M. J. A., & Pacheco, O. R. (2021).

Table 4. Theoretical Propositions and Conceptual Framework

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Code	Theoretical Propositions
P1	Integrating halal principles with sustainable development goals requires destination governance that links normative values with policies and accountability.
P2	Community empowerment strengthens the potential for collaborative governance to generate substantive participation and a more equitable distribution of benefits.
P3	Responsible tourism serves as an operational mechanism that translates policies and participation into practices for managing destination impacts.
P4	Monitoring and adaptive feedback support continuous improvements to policies, community participation, and tourism practices.
P5	The integration of these three dimensions provides a framework for achieving inclusive, ethical, and sustainable halal tourism.

This proposition is a proposed conceptual framework and therefore cannot yet be considered a proven hypothesis. Each proposition needs to be examined for consistency with the selected and synthesized literature, and the overall integration of the concepts is formulated as follows:

$$K = \Phi\ (H, S, I\ (G, E, R), F)$$

Comprehensive integration, with K as the conceptual framework for sustainable halal tourism and FFF as the mechanism for monitoring, evaluation, and feedback. This formulation emphasizes that achieving sustainable halal tourism requires the integration of halal values, sustainability goals, destination governance, community empowerment, and responsible tourism practices. Monitoring and evaluation serve as adaptive mechanisms to refine policies, strengthen participation, and manage the impacts on the destination.. Battour, M., & Ismail, M. N. (2016), Lebrun, A.-M., & Bouchet, P. (2024), López-Guzmán, T. (2017).

The theoretical contribution of this research lies in explaining the mechanisms of institutional, participatory, operational, and adaptive integration within a single conceptual framework. This framework positions sustainable halal tourism as the result of the integration of values, governance, community capacity, and responsible actions to achieve a balance between economic benefits, social justice, and environmental and cultural sustainability. Ansell, C., & Gash, A. (2008). Alonso, A. D., Kok, S., & O'Brien, S. (2018b). Aydın, A. (2020a). This framework is a conceptual proposition that still requires validation through empirical research on halal tourism destinations.

The development of an integrative conceptual framework for sustainable halal tourism is based on the relationships between halal principles, destination governance, community empowerment, and responsible tourism. Destination management plays a role in translating Islamic values, such as trustworthiness and justice, into policies and accountability mechanisms, while community empowerment strengthens participation in decision-making and the equitable distribution of benefits (Scheyvens, 1999; Tosun, 2000). Furthermore, responsible tourism operationalizes these policies and participation through the management of economic, sociocultural, and environmental impacts (Goodwin, 2011). Monitoring and adaptive feedback support the continuous evaluation and improvement of governance. The theoretical contribution of this study lies in the formulation of institutional, participatory, operational, and adaptive integration mechanisms to explain how halal principles can be aligned with the goals of sustainable tourism development, moving beyond a focus

on providing Muslim-friendly services toward destinations that are inclusive, ethical, and sustainable: Battour & Ismail, 2016; WCED, 1987, Cabral, Ó., Lavrador, L., Orduna, P., & Moreira, R. 2024, Da Mota, C. V., Rodrigues, R. I., Palrão, T., & Madeira, A. 2024 .

The development of an integrative conceptual framework for sustainable halal tourism is based on five theoretical propositions, as shown in Table 3, which explain the relationship between halal principles, destination governance, community empowerment, responsible tourism, and adaptive monitoring and evaluation. The first proposition (P1) asserts that integrating halal principles with sustainable development goals requires destination governance capable of translating normative Islamic values—such as trustworthiness, justice, and the public good—into policies, coordination mechanisms, and accountability. These policies, in turn, require community involvement to ensure their implementation aligns with local needs and characteristics.

The second proposition (P2) explains that community empowerment strengthens the effectiveness of collaborative governance through capacity building, access to resources, involvement in decision-making, and the equitable distribution of economic benefits. Empowerment, therefore, is not only an outcome of tourism development but also a mechanism that enables communities to play an active role in determining the direction of destination development. Furthermore, the third proposition (P3) positions responsible tourism as an operational mechanism that translates policies and community participation into concrete actions, including the management of economic impacts, environmental protection, cultural preservation, and respect for local social values. This correlation is reinforced by the fourth proposition (P4), which positions monitoring, evaluation, and adaptive feedback as mechanisms for assessing policy implementation outcomes and improving governance, community participation, and sustainable tourism practices. Monitoring results serve as the basis for subsequent decision-making, ensuring that destination management proceeds as a continuous process of learning and improvement.

Based on the relationship among these four propositions, the fifth proposition (P5) posits that the integration of destination governance, community empowerment, and responsible tourism forms a conceptual framework for explaining the achievement of inclusive, ethical, and sustainable halal tourism. The theoretical contribution of this study lies in its explanation of the mechanisms of inter-dimensional integration—specifically, how halal values are linked to policy, reinforced through community capacity and participation, realized in responsible practices, and refined through adaptive feedback. Thus, sustainable halal tourism is not understood merely as the fulfilment of Muslim-friendly service standards, but as a destination development system that integrates values, institutions, participation, actions, and adaptive learning to achieve a balance between economic benefits, social justice, and cultural and environmental sustainability.

CONCLUSION

1. Sustainable halal tourism is a destination development approach that integrates the values of trust, justice, and the common good with economic, sociocultural, and environmental sustainability. This integration is realized through the synergy of destination governance (G), community empowerment (EEE), and responsible tourism (RRR), which links normative halal values with policies, community participation, responsible practices, and adaptive learning.

2. The theoretical contribution of this study lies in the development of an integrative conceptual framework that explains the mechanisms linking these three dimensions in creating ethical, inclusive, and sustainable destinations. This framework serves as a conceptual proposition that needs to be empirically tested to confirm the interrelationships among the dimensions and their application in various destination contexts.

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(O-45) FROM WASTE TO VALUE: A CIRCULAR HALAL GASTRONOMY FRAMEWORK FOR SUSTAINABLE MUSLIM-FRIENDLY TOURISM

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Abstract

Muslim-friendly tourism is expanding rapidly, increasing the strategic importance of halal gastronomy while intensifying concerns surrounding food waste, resource consumption and sustainable destination development. Although sustainability is increasingly addressed within halal tourism and halal food systems, circular economy principles remain weakly integrated into gastronomy and hospitality. This study investigates how circular practices can be embedded within halal gastronomy without compromising halal integrity and proposes a Circular Halal Gastronomy Framework for sustainable Muslim-friendly destinations.

A two-stage review design combines bibliometric mapping with a Systematic Literature Review guided by PRISMA 2020. Bibliometric analysis of 51 Scopus-indexed publications from 2016 to August 2026 reveals a rapidly emerging but fragmented knowledge base, with 78% of publications appearing in 2025–2026. The subsequent review identifies 21 relevant studies and synthesises evidence across four interconnected themes: Resource Circularity, Halal Integrity and Assurance, Implementation Capacity, and Sustainable Destination Value.

The findings show that Circular Halal Gastronomy extends beyond conventional food-waste management. It integrates waste prevention, value retention, redistribution and recovery with halal sourcing, traceability, assurance, organisational capability and stakeholder participation. These elements collectively support environmental improvement, local economic value retention, SME and community participation, and more resilient tourism destinations. By positioning gastronomy as the connecting mechanism between halal food systems, circular resource management and tourism, the proposed framework offers a distinctive pathway for translating circular economy principles into halal-compliant destination practices and advancing the sustainable halal economy.

Keywords: Circular Halal Gastronomy; Circular Economy; Muslim-Friendly Tourism; Food Waste; Sustainable Tourism

Introduction

Muslim-friendly tourism has developed into a sizeable part of the global tourism economy. The Mastercard–CrescentRating Global Muslim Travel Index (GMTI) 2026 estimated 196 million international Muslim arrivals in 2025 and projects that this figure will reach 262 million by 2030. Growth of this scale places greater expectations on destinations to provide services that respond to Muslim travellers while remaining competitive and sustainable. This is also reflected in the academic literature, where halal tourism has gradually moved beyond questions of religious facilities and service provision towards wider concerns involving destination development, sustainability and responsible tourism (Khan et al., 2025).

A similar development can be observed in the wider halal economy. Muslim consumer expenditure

across major Islamic economy sectors was estimated at approximately US$2.60 trillion in 2024, with halal food remaining the largest consumer sector (State of the Global Islamic Economy (SGIE) Report, 2025/26). Food is therefore relevant not only as a basic requirement of Muslim travellers but also as part of the economic activity created through tourism. Restaurants, local producers, hospitality operators and food businesses all participate in this relationship. Han et al. (2021) show that halal food attributes influence perceived value, satisfaction and behavioural intentions among Muslim travellers, suggesting that food has a role in shaping the destination experience as well as in supporting the local tourism economy.

Yet the expansion of halal food consumption within tourism also raises questions that go beyond availability and certification. Food passes through sourcing, processing, transport, preparation, serving and consumption before reaching the end of its useful life. At each stage, resources may be lost or inefficiently used. Bux et al. (2022) position halal food sustainability within a wider environmental, economic and social context, extending beyond certification and compliance. Rahman et al. (2024) similarly associate halal integrity with responsible sourcing, environmental protection, transparency and supply-chain accountability.

The problem becomes particularly visible when food reaches hospitality and food service operations. Hotels, restaurants and catering establishments deal with uncertain demand, menu variety, portion sizes, storage, preparation losses and customer leftovers. Organisational, operational, behavioural and consumer-related factors were recognised as important sources of food waste in hospitality and food service by Dhir et al. (2020). Apart from the environmental consequences, such waste also represents lost value in ingredients, labour, water, energy and logistics. Evidence from a halal flight-catering operation further demonstrated that waste measurement and resource-efficiency measures can be incorporated within halal food production without weakening halal requirements (Thamagasorn & Pharino, 2019).

This is where circular economy thinking becomes particularly relevant. Instead of viewing waste primarily as something to be managed after consumption, circularity seeks to prevent avoidable losses and retain the value of resources for longer. Within hospitality and food service, this may include better forecasting, procurement and inventory control, portion management, redistribution of edible surplus, reuse, recycling and recovery. Such an approach changes the emphasis from disposal towards prevention and value retention (Dhir et al., 2020). What remains less developed is how these practices fit within a halal gastronomic system, where resource efficiency must coexist with halal integrity, food safety and the expectations of Muslim travellers.

Research in halal tourism is beginning to engage more directly with sustainability, but the development remains uneven. Khan et al. (2025), in their review of 62 publications, identified sustainability, Sustainable Development Goals and technological systems as emerging areas within halal tourism scholarship. At the same time, they note that religious, environmental and technological concerns are often discussed separately. Recent halal food research also points towards the need for stronger links between food systems, tourism and sustainable development (Rejeb et al., 2021). This suggests that the challenge is no longer simply to introduce sustainability into halal tourism, but to understand how different parts of the tourism and food system can work together.

Gastronomy provides one possible point of connection. It encompasses more than the availability of halal food; it brings together sourcing, preparation, restaurants, hospitality, culinary heritage, visitor experience and the relationship between food and place. It also connects tourism consumption with local producers, small businesses and communities. In this sense, gastronomy provides a setting in

which questions of halal integrity, resource use, waste and local economic value can be considered together rather than as separate issues.

The preliminary bibliometric analysis undertaken for this study indicates that these connections remain weak in the published literature. The master Scopus corpus comprised 51 publications covering halal, sustainability, circularity, food systems, hospitality and tourism from 2016 to August 2026. Separate diagnostic Scopus searches identified ten publications linking circular economy with halal, two linking circular economy with halal tourism, and none explicitly combining circular economy with halal gastronomy. These diagnostic results represent different search scopes rather than subsets counted within the master corpus. Within the 51-publication corpus, four records mentioned circular economy in their titles, abstracts or keywords. These findings suggest that relevant knowledge is dispersed across separate research streams, providing a basis for integrating the evidence through a systematic literature review.

This study therefore examines how circular economy principles can be integrated into halal gastronomy to support sustainable Muslim-friendly tourism and destination development. A two-stage approach combines bibliometric analysis with a systematic literature review guided by PRISMA 2020. The bibliometric stage profiles the research landscape, while the systematic review synthesises circular practices, enabling conditions, barriers and associated outcomes. Together, these stages inform the development of a Circular Halal Gastronomy Framework.

Literature Review

2.1 Muslim-Friendly and Halal Tourism

Halal tourism generally refers to tourism products, services and environments that accommodate the religious requirements and values of Muslim travellers (Azam et al., 2019). These may include access to halal food, prayer facilities, suitable accommodation and services that respect Islamic principles. The terminology nevertheless remains varied, with terms such as halal tourism, Muslim-friendly tourism, Islamic tourism and halal-friendly tourism often used with different emphases. Recent reviews indicate that the field has expanded considerably, although conceptual and operational inconsistencies remain, particularly in relation to standardisation and the scope of halal tourism services (Abdullah et al., 2025).

Earlier studies tended to focus on religious attributes, destination image, traveller satisfaction and behavioural intentions. More recent work has broadened towards sustainability, technology and destination development. Khan et al. (2025), reviewing 62 publications, identify sustainability integration, Sustainable Development Goals and technological systems as emerging streams within halal tourism research. This shift is relevant because it moves the discussion beyond the provision of Muslim-friendly services towards the wider contribution of tourism activities to destination sustainability.

2.2 Halal Gastronomy and Culinary Tourism

Gastronomy extends beyond food provision to include culinary practices, food culture, preparation, consumption, heritage and the relationship between food and place. Within tourism, these elements contribute to destination identity and visitor experience while also supporting restaurants, local producers and communities. In a halal setting, these activities carry the additional requirement that halal integrity is maintained throughout sourcing, preparation, handling and consumption.

Halal tourism research has often treated food as one destination attribute among many. Yet food may

have a more substantial role in shaping the tourism experience. Han et al. (2021) found that perceived halal food performance strengthened destination trust and attachment and, in turn, traveller retention. Research on halal culinary tourism similarly suggests that cuisine can influence destination trust and intention to visit, indicating that halal food is increasingly viewed as part of the destination experience rather than merely a dietary requirement.

Even so, much of the existing literature remains centred on food availability, certification, restaurant choice and visitor behaviour. Less attention has been paid to the wider gastronomic system, including sourcing, production, hospitality operations, consumption and post-consumption resource flows. This wider view is important for sustainability because environmental and resource impacts arise throughout the food journey, not simply at the point of consumption.

2.3 Sustainable Halal Food Systems

Halal food scholarship has gradually expanded from questions of permissibility and certification towards food integrity, traceability and sustainability. Bux et al. (2022) show that halal food sustainability encompasses environmental, economic and social considerations alongside certification and supply-chain transparency. Their review also illustrates how technologies such as blockchain may strengthen both traceability and the reliability of sustainability information.

This broader systems perspective is also evident in halal supply-chain research. Rejeb et al. (2021) link halal integrity with sustainable supply-chain practices, while Masudin et al. (2022) identify traceability as an important mechanism for strengthening procurement and assurance. Together, these studies show that halal integrity must be maintained across sourcing, production, logistics and distribution rather than considered only at the point of consumption.

However, this literature remains concentrated largely on certification, traceability, technology and supply-chain performance. Far less is known about what happens when halal food enters hotels, restaurants, catering operations and other tourism-related settings, where surplus food and resource losses become more visible.

2.4 Circular Economy, Food Waste and Resource Efficiency

The circular economy challenges the conventional linear pattern of extraction, consumption and disposal by seeking to minimise resource loss and retain value for as long as possible. In food systems, this may involve preventing avoidable waste, redistributing edible surplus, recovering useful materials and converting unavoidable residues into productive inputs. The emphasis therefore shifts from dealing with waste after it occurs towards reducing its generation and preserving resource value.

Hospitality and food service are particularly exposed to food waste because losses may occur during procurement, storage, preparation, serving and consumption. Dhir et al. (2020) identify organisational, operational and behavioural factors as important causes of such waste and argue for more integrated approaches to prevention and management. Procurement practices, menu design, portioning, employee behaviour and consumer choices can all influence the amount of waste generated.

Halal food research provides some evidence that these principles can be applied without compromising religious requirements. Thamagasorn and Pharino (2019), for example, used material-flow and food-waste analysis within a halal flight-catering operation to identify opportunities for improved resource efficiency. Their study is particularly useful because it links halal food production directly with tourism and demonstrates the practical compatibility of halal integrity and waste reduction.

2.5 Circularity in Hospitality and Tourism

Hotels, restaurants and catering operations occupy a critical position between food supply chains and final consumption. Because waste can arise before, during and after service, circularity in hospitality requires more than end-of-pipe disposal. Dhir et al. (2020) highlight the operational and stakeholder dimensions of food-waste management, while Filimonau et al. (2021) show that restaurant food waste is also shaped by market, cuisine and operational characteristics.

More recent studies move beyond waste management towards circular practices. Cardenas et al. (2024), reviewing 51 studies, found that hospitality circularity is concentrated mainly around prevention, minimisation and recycling, while also drawing attention to customer participation. Ally et al. (2024) similarly identify both opportunities and implementation challenges in moving hotel food-waste practices towards a circular-economy model.

Evidence from Malaysia adds a useful contextual dimension. Kasavan et al. (2022) identify several drivers of food waste within hotel operations, while Chang et al. (2025) show that practices such as food donation and upcycling are influenced by organisational pressures, environmental beliefs and perceived benefits. Arsat et al. (2026) likewise report that food-waste measurement and reduction initiatives within the Malaysian food service sector are increasing, although the evidence remains fragmented and often short-term.

Taken together, this literature shows that circular hospitality depends on operational efficiency, waste prevention, value recovery and stakeholder participation. Its connection with halal food integrity and Muslim-friendly tourism, however, remains much less developed.

2.6 Conceptual Convergence and Research Gap

The literature reviewed above points to several bodies of knowledge that are relevant to Circular Halal Gastronomy, although they have largely developed separately. Halal tourism research explains Muslim-friendly destination requirements and increasingly engages with sustainability, while hospitality and food service studies provide a more developed body of knowledge on food-waste prevention, circular practices and resource efficiency (Dhir et al., 2020; Cardenas et al., 2024).

A smaller stream begins to connect these areas more directly. Sari et al. (2024), for example, show that green management, digital transformation and halal business management can contribute to ecological, social and economic performance among halal culinary MSMEs. Saffinee and Jamaludin (2024) also connect halal gastronomy with tourism, although the emphasis remains largely on food quality, handling and halal compliance rather than circular resource use.

The research gap therefore lies in integration rather than absence. Circular hospitality research explains how food waste and resource loss may be reduced, while halal tourism and gastronomy research explains how halal integrity and food experiences contribute to destination value. What remains insufficiently understood is how these perspectives can operate together within a gastronomic system that protects halal integrity while reducing resource loss and creating economic, environmental and societal value.

Accordingly, this study positions Circular Halal Gastronomy at the intersection of halal food integrity, gastronomy and hospitality, circular resource management, and Muslim-friendly tourism. Rather than imposing predetermined circular dimensions, the subsequent SLR examines the practices, enabling conditions, barriers and outcomes emerging from these areas. Their synthesis provides the basis for developing the proposed Circular Halal Gastronomy Framework.

Methodology

This study adopted a two-stage review design comprising descriptive bibliometric analysis followed by a systematic literature review (SLR). The bibliometric stage profiled research connecting halal, sustainability, circular economy, food systems and tourism. The SLR examined the practices, enabling conditions, barriers and sustainability outcomes relevant to developing the proposed Circular Halal Gastronomy Framework. These stages served complementary purposes: the first characterised the research landscape, while the second examined the substantive evidence. Study identification and selection were documented using the PRISMA 2020 reporting framework (Page et al., 2021).

1.1 Bibliometric Analysis

Scopus provided the bibliometric corpus of 51 records exported in BibTeX format on 11 August 2026. The records were analysed descriptively using Python scripts to calculate publication-year and document-type distributions, citation statistics and author-keyword frequencies. This approach supported an overview of the development and composition of the literature (Donthu et al., 2021). The procedure involved descriptive bibliometric profiling rather than citation-network or co-occurrence mapping.

Author keywords were available for 38 records. Selected terms, including “circular economy” and “gastronomy”, were examined within titles, abstracts and available author keywords. Exact-term counts were distinguished from broader subject relevance: a publication could address food preparation, hospitality or circular resource practices without explicitly using the word “gastronomy”. Missing keywords were treated as unavailable metadata rather than evidence that a topic was absent.

Separate diagnostic Scopus searches explored narrower combinations of halal, circular economy, tourism and gastronomy. Their retrieval counts were considered separately and were not added to the 51-record master corpus. The bibliometric corpus included several publication types to characterise the wider research landscape. Its records were subsequently reassessed against the narrower SLR eligibility criteria; inclusion in the bibliometric analysis did not automatically qualify a publication for the thematic synthesis.

3.2 Systematic Literature Review

Following the bibliometric analysis, the SLR examined evidence relevant to integrating circular economy principles into halal gastronomy and Muslim-friendly tourism. Because directly integrated research remains limited, the review considered both halal-specific publications and related hospitality and food-system literature with transferable relevance. This approach allowed established circular practices to inform framework development while retaining halal assurance as a distinct consideration.

The review addressed the following overarching research question:

RQ: How can circular economy principles be integrated into halal gastronomy to support sustainable Muslim-friendly tourism and destination development?

Four supporting questions guided the examination of the literature:

- RQ1: What circular and waste-reduction practices are applicable to halal gastronomy, hospitality and food service?
- RQ2: What factors enable the implementation of these practices?
- RQ3: What barriers constrain their implementation?

- RQ4: What environmental, economic and societal outcomes are associated with these practices?

3.2.1 Information Sources and Search Strategy

The review used Scopus as the primary bibliographic database and SpringerLink as a complementary publisher platform. The available exports contained 51 Scopus records and 154 SpringerLink records, providing 205 records before duplicate removal. Table 1 presents the search expressions and corresponding export counts.

The search strategy combined three conceptual blocks: halal; circularity and sustainability; and food, hospitality and tourism. Circularity-related terms included food waste, waste management, waste reduction, zero waste, resource efficiency and waste valorisation. Sectoral terms included gastronomy, culinary activities, cuisine, restaurants, hotels, food service, tourism and related food systems. Boolean operators connected these concepts, with alternative terms used to accommodate differences in disciplinary terminology.

Requiring “gastronomy” in the initial diagnostic search returned no results. Broader culinary, hospitality, tourism and food-system terminology was therefore used, with gastronomy retained as an optional term. This avoided making eligibility dependent on the use of one word. The title reflects the conceptual application of the review to halal gastronomy, while the search strategy captures the wider evidence needed to examine that application.

Table 1. Search Strings used for the Bibliographic Platforms and the Results Obtained

Information source	Search string	Records identified
Scopus	TITLE-ABS-KEY (halal AND ("circular economy" OR circular* OR sustainab* OR "food waste" OR "waste management" OR "waste reduction" OR "zero waste" OR "resource efficiency" OR "waste valorization" OR "waste valorisation") AND (gastronom* OR culinary OR cuisine OR "food tourism" OR "culinary tourism" OR tourism OR tourist* OR hospitality OR hotel* OR restaurant* OR "food service" OR "food system" OR "food systems" OR "food supply chain" OR "halal food"))	**51**
SpringerLink	halal AND ("circular economy" OR sustainable OR "food waste" OR "waste management" OR "waste reduction" OR "zero waste" OR "resource efficiency" OR "waste valorization" OR "waste valorisation") AND (gastronomy OR culinary OR cuisine OR "food tourism" OR "culinary tourism" OR hospitality OR hotel OR restaurant OR "food service" OR tourism OR "halal food" OR "food system" OR "food supply chain")	**154**
Total before deduplication		**205**

3.2.2 Inclusion and Exclusion Criteria

Eligible publications comprised English-language journal articles, reviews and relevant scholarly book chapters published between 2016 and 31 August 2026. Publications addressed halal food, gastronomy, hospitality, Muslim-friendly tourism or related food systems. General hospitality and food-system publications were also considered where their circular practices, implementation conditions, barriers or sustainability outcomes were transferable to the research questions.

Relevant scholarly book chapters were retained because they formed a substantial part of the emerging literature and could provide useful conceptual or contextual evidence. Conference papers, standalone books, abstracts and non-scholarly publications fell outside the eligible publication types.

Publications were excluded where they concerned unrelated halal sectors, referred to sustainability or waste only incidentally, or examined technical processes without sufficient transferable relevance. Publications outside the specified period or language criteria were also excluded. Table 2 summarises

the inclusion and exclusion criteria.

Transferability was distinguished from halal permissibility. Inclusion of a general food-system publication did not establish that its ingredients, recovery processes or handling practices complied with halal requirements. Such evidence informed potentially applicable mechanisms, with halal assurance remaining a separate condition of their implementation.

Table 2. Inclusion and Exclusion Criteria Table

Criterion	Inclusion	Exclusion
Period	2016–August 2026	Publications outside the review period
Language	English	Non-English publications
Publication type	Peer-reviewed journal articles, reviews and relevant scholarly book chapters	Editorials, news reports, dissertations, abstracts and non-scholarly publications
Halal relevance	Halal food, gastronomy, hospitality, Muslim-friendly tourism and related food systems; or hospitality and food-system evidence with transferable relevance to the research question.	Halal finance, cosmetics, pharmaceuticals and unrelated halal sectors
Circular/sustainability relevance	Circular economy, sustainability, food waste, waste reduction, resource efficiency, redistribution, recovery and valorisation	Incidental reference to sustainability or waste
Sectoral relevance	Food systems, restaurants, hotels, catering, hospitality, food service, tourism and related supply chains	Technical or laboratory studies without transferable relevance to the research question
Bibliographic integrity	Verifiable scholarly publication and DOI where assigned	Inconsistent or unverifiable bibliographic records

3.2.3 Screening and Data Synthesis

The selection process was reconstructed from the available exports and retrievable reports. Duplicate records were identified using DOI matching and normalised titles. The remaining records were screened using titles and available abstracts. Where potentially relevant reports were retrieved, their relevant full-text sections were assessed against the eligibility criteria.

Data extraction recorded publication context, circular practices, halal considerations, enabling conditions, implementation barriers and reported sustainability outcomes. Evidence from empirical studies was distinguished from conceptual discussions, reviews and modelling exercises. This distinction prevented proposed benefits or simulated results from being presented as demonstrated outcomes in tourism businesses.

The evidence was organised under four analytical domains: Resource Circularity, Halal Integrity and Assurance, Implementation Capacity, and Sustainable Destination Value. Publications could contribute to more than one domain. Comparison across these domains informed the relationships proposed in the Circular Halal Gastronomy Framework. Given the diversity of publication designs and contexts, the synthesis was qualitative; no pooled effect estimate or formal risk-of-bias assessment was undertaken.

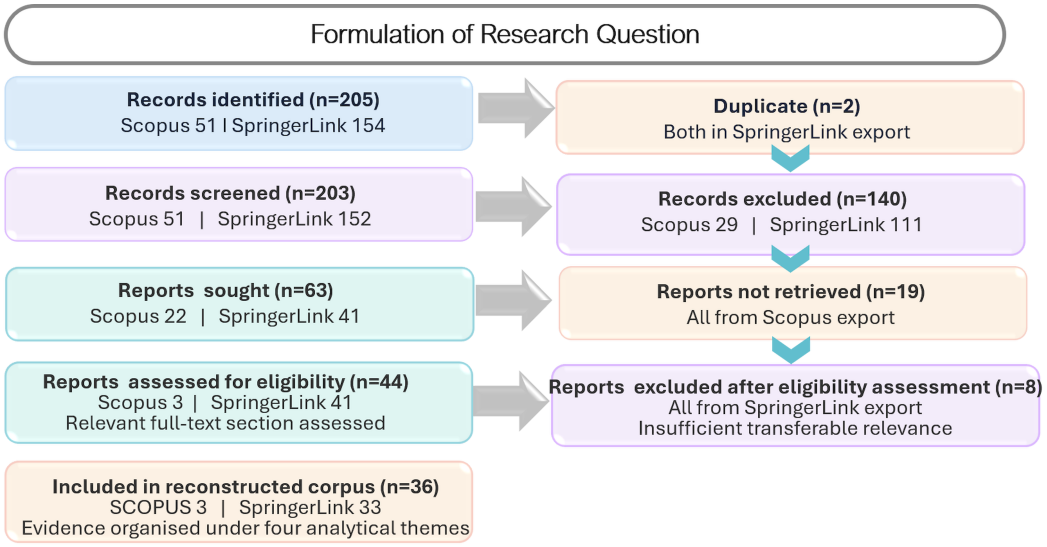
2.2 **PRISMA 2020 Screening**

The supplied exports contained 205 records: 51 from Scopus and 154 from SpringerLink. Two duplicates were removed, leaving 203 records for title and abstract screening. At this stage, 140 records were excluded and 63 reports were sought for retrieval.

Nineteen reports were not retrieved through the attempted publisher or repository routes. Relevant

full-text sections of the remaining 44 reports were assessed, and eight were excluded because they did not provide sufficiently transferable evidence for the review. The reconstructed corpus therefore comprised 36 publications: three from Scopus and 33 from SpringerLink. Figure 1 presents the selection process, while the accompanying screening record documents individual decisions and exclusion reasons.

The unretrieved reports limit the coverage of the synthesis. Accordingly, the review supports conceptual framework development rather than an exhaustive assessment of all relevant evidence or empirical validation of the proposed framework.



Note: The 19 unretrieved reports were not excluded for lack of relevance. Selection reconstructed from available exports and retrieved reports.

Figure 1. PRISMA 2020 study selection process *Source: Developed by the authors based on Page et al. (2021).*

Findings

1.1 Bibliometric Findings

The 51-record Scopus corpus indicates a recent and diverse research landscape. Forty records (78.4%) carried publication years of 2025–2026. Book chapters accounted for 26 records (51.0%), followed by conference papers with 11 (21.6%), journal articles with seven (13.7%), reviews with five (9.8%) and books with two (3.9%). These figures describe the bibliometric corpus rather than the narrower set selected for thematic synthesis.

Author keywords were available for 38 records. The exact phrase “circular economy” appeared in the title, abstract or author keywords of four records, while the exact word “gastronomy” appeared in none of these fields. This indicates limited explicit use of the terminology, rather than an absence of related hospitality, culinary or food-system subject matter.

The combination of publication types and terminology illustrates the breadth of the research landscape. Relevant contributions occur across halal tourism, food systems, assurance and sustainability, requiring substantive screening rather than reliance on exact-word matching alone.

Taken together, the bibliometric findings suggest that the constituent areas of Circular Halal

Gastronomy are already present in the literature but remain dispersed across separate research streams

2.2 Systematic Literature Review Findings

The 36-publication reconstructed corpus provided complementary evidence across four analytical domains. Table 3 summarises representative publications and indicative sub-themes. The synthesis distinguishes halal-specific evidence from general food-system mechanisms whose application to halal gastronomy requires contextual interpretation. Background literature discussed in Section 2 is not automatically counted within this selected corpus.

Resource Circularity concerns retaining food and resource value through prevention, preservation, redistribution and recovery. Cole et al. (2018) connect food preservation, loss recovery and redistribution with a systems approach to food security. Febriandika et al. (2025) identify closed-loop systems, resource recovery and coordination priorities in an ANP model of halal food supply chains. Bunge et al. (2022) add a caution: sustainability benefits attributed to food-system technologies require assessment across environmental, social and economic dimensions. These contributions support considering resource flows throughout the food cycle, without assuming that every proposed practice delivers measurable benefits in tourism businesses.

Table 3. Thematic synthesis of the reconstructed evidence corpus

Main theme	Indicative sub-themes	Representative articles
Resource Circularity	Food-waste prevention; preservation and shelf-life extension; inventory management; surplus redistribution; resource recovery; valorisation	Cole et al. (2018); Bunge et al. (2022); Febriandika et al. (2025)
Halal Integrity and Assurance	Responsible sourcing; halal traceability; transparency; supply-chain risk management; verification of recovered ingredients and processes	Rahman et al. (2024); Febriandika et al. (2025); Rashid et al. (2026)
Implementation Capacity	Organisational capability; digital infrastructure; stakeholder coordination; governance; training; implementation barriers	Khan et al. (2025); Febriandika et al. (2025); Winoto et al. (2026)
Sustainable Destination Value	Resource efficiency; environmental responsibility; community participation; local enterprise development; sustainable tourism; destination development	Bunge et al. (2022); Khan et al. (2025); Nuryana et al. (2026); Winoto et al. (2026)

Note: The thematic categories are non-exclusive. Individual studies may contribute to more than one theme.

Halal Integrity and Assurance concerns maintaining confidence in sourcing, handling and provenance while pursuing circular practices. Rahman et al. (2024) relate halal meat production and consumption to ethical and sustainability considerations. Febriandika et al. (2025) connect supply-chain information problems, including halal-label falsification, with circular-economy priorities. Rashid et al. (2026) demonstrate provenance and data-integrity mechanisms in a fruit-chain blockchain prototype. The latter provides transferable traceability evidence, not proof of halal certification or the permissibility of recovered ingredients. The framework therefore treats halal assurance as an explicit condition requiring appropriate verification.

Implementation Capacity encompasses the organisational, technological and institutional conditions supporting adoption. Khan et al. (2025) discuss environmental responsibility, technological innovation and coordinated halal-tourism development. Febriandika et al. (2025) identify operational and coordination priorities within halal food supply chains. Winoto et al. (2026) examine policy, investment, environment, innovation and communication in halal tourism villages. Together, these publications suggest that implementation requires capabilities and coordination alongside technical

practices. Their differing designs do not establish a single causal model applicable to all hospitality businesses.

Sustainable Destination Value connects operational resource management with wider environmental responsibility and local development. Khan et al. (2025) and Nuryana et al. (2026) position sustainability and governance within an expanding halal-tourism agenda. Winoto et al. (2026) report exploratory associations between tourism-village sustainability indicators and perceived development outcomes, rather than causal effects. Bunge et al. (2022) reinforce the importance of evaluating multiple sustainability dimensions. These findings inform potential destination benefits; they do not demonstrate that a complete Circular Halal Gastronomy system has already produced those benefits.

The four themes are closely related rather than independent. Resource Circularity identifies what is done; Halal Integrity and Assurance establishes the conditions that must be protected; Implementation Capacity determines whether circular practices can be realised; and Sustainable Destination Value captures the outcomes generated. This relationship provides the conceptual foundation for the Circular Halal Gastronomy Framework developed in the following section.

3.3 **Development of the Circular Halal Gastronomy Framework**

The framework integrates the four analytical domains into a conceptual system linking food-resource practices, halal assurance, implementation capability and intended destination value. It represents an interpretation of complementary evidence rather than an empirically validated causal model.

Resource Circularity forms the operational component. Preservation, prevention, redistribution and recovery provide potential ways to retain resource value (Cole et al., 2018; Febriandika et al., 2025). The broader hospitality literature discussed in Section 2 adds practical examples such as forecasting, inventory control and portion management. These operational examples extend the food-system mechanisms into hospitality settings.

Halal Integrity and Assurance accompanies sourcing, preparation, consumption and recovery. Ethical sourcing and supply-chain accountability provide relevant foundations (Rahman et al., 2024), while digital provenance mechanisms can support information integrity (Rashid et al., 2026). Within the proposed framework, recovered ingredients, redistribution routes and handling processes require appropriate halal and food-safety verification. Technology supports this process but does not replace certification or competent assessment.

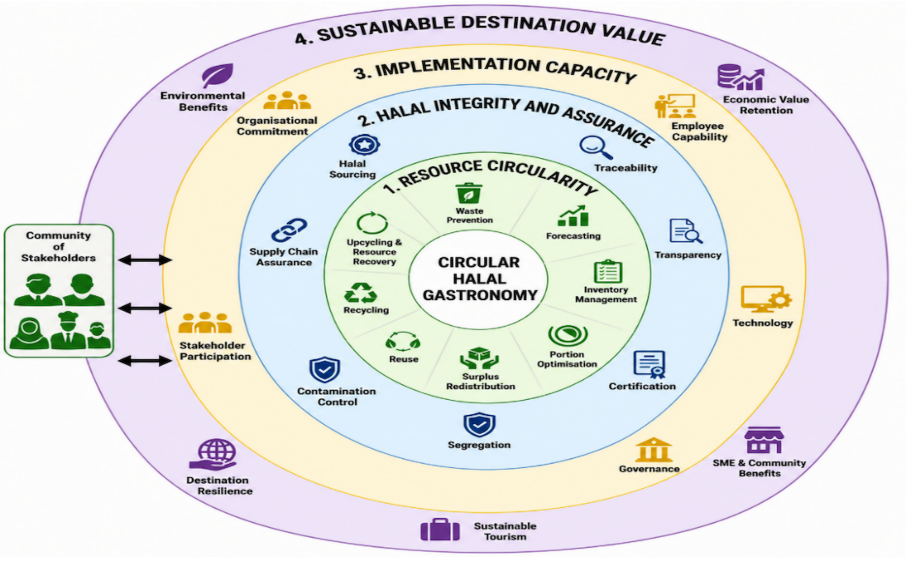


Figure 2. Circular Halal Gastronomy Framework for Sustainable Muslim-Friendly Tourism

Source: Developed by authors

Implementation Capacity enables adoption through management commitment, staff capability, technology, stakeholder coordination and governance. Khan et al. (2025), Febriandika et al. (2025) and Winoto et al. (2026) provide complementary evidence concerning these conditions across tourism and food supply chains. Their transfer to individual hotels, restaurants and catering businesses depends on local resources, infrastructure and institutional arrangements.

Sustainable Destination Value captures intended environmental, economic and community contributions. Halal-tourism research supports examining destination development alongside religious service requirements (Khan et al., 2025; Nuryana et al., 2026). The framework proposes that better resource management, implemented with assurance and organisational support, may contribute to such value. Performance should be monitored rather than presumed, particularly because sustainability trade-offs can occur (Bunge et al., 2022).

Figure 2 presents the four components as interconnected layers.

Implementation Capacity enables Resource Circularity, while Halal Integrity and Assurance governs its implementation. These practices may generate Sustainable Destination Value, with outcome monitoring informing further improvements. The layers represent an integrated system rather than sequential stages; the proposed relationships require empirical testing.

Discussion

The synthesis supports examining Circular Halal Gastronomy as a system connecting resource practices, halal assurance, implementation capability and destination development. The background hospitality literature explains established food-waste management concerns, while the reconstructed corpus adds complementary evidence on food-resource retention, halal supply chains and destination governance. Bringing these contributions together is a conceptual integration; it does not establish that all included publications directly investigated circular halal tourism.

A central implication is that resource management should begin before disposal. Preservation and loss recovery can retain value in food systems (Cole et al., 2018), while circular halal supply-chain modelling identifies material, financial and information flows as connected management concerns (Febriandika et al., 2025). For tourism businesses, these mechanisms suggest examining procurement, storage, preparation and service alongside surplus handling. The appropriate mix of practices depends on operational context, food safety and halal requirements.

Assurance and implementation capacity are equally important. Rahman et al. (2024) connect halal consumption and production with ethical responsibilities, while Rashid et al. (2026) demonstrate how digital systems can strengthen provenance information. Neither establishes that digital traceability alone ensures halal compliance. Organisational and institutional support remains necessary, consistent with the coordination and development issues examined by Khan et al. (2025) and Winoto et al. (2026).

Destination-level benefits should therefore be treated as propositions for evaluation. Nuryana et al. (2026) identify a widening halal-tourism agenda involving sustainability and governance, while Winoto et al. (2026) provide exploratory village-level evidence. Bunge et al. (2022) caution that food-technology sustainability claims often lack balanced assessment across dimensions. Future testing of Circular Halal Gastronomy should measure resource losses, costs, assurance performance and

community participation rather than infer destination benefits from the adoption of individual practices.

Conclusion

This study examined how circular economy principles can inform halal gastronomy within sustainable Muslim-friendly tourism. Descriptive bibliometrics profiled 51 Scopus records, while screening reconstructed from two available exports provided a 36-publication corpus. Comparison across Resource Circularity, Halal Integrity and Assurance, Implementation Capacity, and Sustainable Destination Value informed the proposed framework.

The framework positions resource retention and recovery alongside the assurance and capabilities required for acceptable implementation. Gastronomy provides a practical setting connecting sourcing, preparation, hospitality service, consumption and subsequent resource flows. The framework offers an organising basis for research and business application, while its proposed relationships remain to be empirically tested.

Coverage is limited by the two information sources and the 19 reports not retrieved. General food-system evidence was transferred conceptually and does not establish halal permissibility or destination-level effects. The absence of formal risk-of-bias assessment also limits conclusions about evidence strength. Further research should test the framework in specific destinations and business settings using environmental, operational and community indicators.

7. Implications

The study contributes conceptually by bringing together bodies of literature that have largely developed in parallel. Halal tourism research has concentrated on Muslim-friendly services, destination attributes and increasingly sustainability, while circular hospitality research has focused on waste reduction, resource efficiency and value recovery. By integrating these perspectives, the proposed framework positions halal integrity as an embedded condition of circularity rather than a separate compliance requirement, while also extending circular food practices towards destination-level outcomes.

A halal-certified hotel could apply the framework by training staff and coordinating suppliers (Implementation Capacity), forecasting buffet demand and preparing smaller batches (Resource Circularity), and maintaining traceability, segregation and food-safety controls (Halal Integrity and Assurance). Monitoring waste per guest meal, costs and local purchasing would indicate Sustainable Destination Value and guide improvements. Redistribution would be limited to safe, unserved surplus.

At destination and policy level, Circular Halal Gastronomy also creates opportunities to connect sustainability with local economic participation. Policies that support halal SMEs, food redistribution networks, local sourcing, circular-food innovation and shared recovery infrastructure can help retain more value within destinations while reducing resource loss. Collaboration among tourism authorities, halal certification bodies, hospitality operators, local producers, communities and technology providers may therefore be more effective than treating halal assurance, tourism sustainability and waste management as separate policy areas.

As an emerging conceptual framework, the study also opens several avenues for future research. Empirical studies could test the relationships among the four framework components across different Muslim-friendly destinations, compare adoption between hotels, restaurants, catering and culinary SMEs, and examine how digital traceability, consumer participation and local governance influence

circular practices. Further research may also explore how destination-specific regulatory, cultural and infrastructural conditions shape the transition from conventional halal gastronomy towards more circular and regenerative models.

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(O-46) DO HUMANITARIAN ISSUES INFLUENCE TRAVEL DECISION? EXAMINING BOYCOTT ATTITUDE AND REVISIT INTENTION TOWARD HALAL DESTINATION

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Abstract

Purpose: This study aims to examine how religiosity, ethical consumption, attitude toward boycott, halal destination attributes, and destination image influence destination satisfaction and revisit intention toward Türkiye as a halal tourism destination. The study is positioned within the context of global humanitarian issues and explores whether value-based considerations contribute to tourism-related evaluations.

Design/methodology/approach: This research employed a quantitative survey approach. Data were collected through an online questionnaire from 100 respondents who had visited Türkiye and were aware of global humanitarian issues. The data were analyzed using partial least squares structural equation modelling (PLS-SEM). The analysis involved measurement model assessment, structural model assessment, and hypothesis testing.

Findings: The findings show that religiosity and ethical consumption have positive and significant effects on attitude toward boycott. However, attitude toward boycott does not significantly influence destination satisfaction. In contrast, halal destination attributes and destination image positively and significantly affect destination satisfaction, with halal destination attributes showing the stronger effect. Destination satisfaction also has a strong positive effect on revisit intention. These results indicate that value-based factors shape boycott attitude, while satisfaction and revisit intention are mainly driven by tourists' direct destination experience.

Originality/value: This study contributes to halal tourism literature by integrating attitude toward boycott into a tourism behavior model. It emphasizes the difference between the development of the ethical attitude and the development of the satisfaction of destination. It reveals that the humanitarian consciousness can influence the moral attitudes, but the aim to come back to Türkiye is mostly constructed via the contentment of halal tourist experiences.

Keywords: Halal tourism, Religiosity, Ethical consumption, Attitude toward boycott, Satisfaction of destination, Revisit intention

(O-47) PANDEMICS FROM ISLAMIC PERSPECTIVE – LESSONS LEARNT FROM COVID19.

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Abstract

Humans have endured pandemics from time immemorial. The pandemic of COVID19 caused by Coronavirus, is just 60-140 nm in diameter. It is submicroscopic, and per scientific knowledge, is the smallest and least valuable known living thing. Five events which are universally predominant during this pandemic are: fear, hunger, loss of wealth, loss of life and loss of provisions. It is amazing that the Qur'an confirms these five events as a test for humanity in Surah Al- Al-Baqara, verse 155.

As far as the vaccines are concerned, although Islam gives dramatic relaxation in its ruling about Halal or Haram, in emergency situations, like pandemics, however, strictly from Fiqah point of view, both Moderna and Pfizer vaccines manufactured in the USA were 100 % Halal, as all the ingredients in the both the vaccines are either plant based or synthetic. The third vaccine manufactured in the USA; the Johnson&Johnson has alcohol (2.04 mg/0.5 ml) in it. Still, as the quantity is small and it will not cause intoxication, hence, the scholars have opined that it is also Halal.

In the UK, Oxford-Astra Zeneca marketed their vaccine produced in the Human Embryonic Kidney 293 cell line (HEK293). Wifaqul Ulama, UK categorized the Human Embryonic Kidney 293 cell line (HEK293) as synthetic, hence declared the vaccine as Halal (personal communication).

In conclusion, fifteen centuries back Islam gave clear-cut solutions to the problems like pandemics. If we practically follow these universal guidelines, in addition to using vaccines, the world will easily be able control such problems.

Keywords: , coronavirus, COVID-19, social distancing, quarantine, vaccines.

(O-48) BUILDING A TÜRKIYE HALAL HEALTH CORRIDOR FOR TRUSTED AND SUSTAINABLE MEDICAL TOURISM

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Abstract

Türkiye received 1,506,442 international health visitors in 2024 and generated United States dollars 3.023 billion in health-tourism revenue, demonstrating substantial capacity for cross-border care. Yet clinical capability and Muslim-friendly amenities alone do not create sustained patient confidence. International Muslim patients require credible assurance across clinical quality, halal pharmaceuticals and nutrition, privacy and dignity, culturally competent care, transparent pricing, ethical promotion, continuity of care and Shariah-compatible financial protection. Fragmented standards, variable service claims, insufficient cross-border coordination and weak post-treatment pathways continue to limit trust and scalability.

This study develops a governance and implementation pathway for a Türkiye-led halal health corridor serving Organisation of Islamic Cooperation markets. It uses comparative qualitative analysis of policies, standards and health-tourism practices in Türkiye, Malaysia, Indonesia, Thailand and selected Gulf countries. The analysis examines institutional roles and coordination across hospitals, halal certification bodies, pharmaceutical and medical-device suppliers, tourism facilitators, digital-health providers, insurers and takaful operators.

The study proposes a five-stage Halal Healthcare Ecosystem Maturity Model: Muslim-friendly accommodation; culturally competent service delivery; independently assured halal healthcare; integrated domestic ecosystems; and interoperable cross-border health corridors. Preliminary findings indicate that the final stage depends on three enabling conditions: risk-based accreditation combining clinical and halal assurance; a regulated patient-navigation pathway for pre-treatment information, consent, price transparency and post-treatment follow-up; and financial protection through takaful-compatible products. The framework embeds sustainability through traceable procurement, prevention of avoidable pharmaceutical and clinical-supply waste, digital documentation that reduces duplication, and responsible resource management throughout the patient journey.

The proposed corridor shifts halal medical tourism from fragmented service claims to trusted health infrastructure. It offers policymakers, providers, certifiers and financial institutions a practical route to improve patient dignity, safety and continuity of care, while supporting sustainable growth in Türkiye’s health-tourism economy and collaboration with Organisation of Islamic Cooperation markets.

Keywords: Halal healthcare, medical tourism, accreditation, takaful, sustainable health systems

(O-49) THE LEGAL FRAMEWORK OF A SUSTAINABLE HALAL ECONOMY: HALAL CERTIFICATION, CONSUMER PROTECTION AND CIRCULAR HALAL VALUE CHAINS

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Abstract

The rapid development of the global halal economy has transformed halal from a concept primarily considered within the framework of religious compliance into a multidimensional economic ecosystem encompassing “food, pharmaceuticals, cosmetics, logistics, finance, tourism, and emerging technologies.” This transformation has also brought significant legal challenges concerning halal certification, consumer protection, traceability, contractual liability, and the sustainability of halal value chains. Against this background, this study examines the legal framework necessary for establishing a sustainable halal economy, with particular emphasis on halal certification, consumer protection, and circular halal value chains. Ultimately, the study argues that halal compliance and sustainability should not be regarded as two independent objectives, but rather as complementary dimensions of the same economic ecosystem. Such an approach may contribute to the development of a more transparent, responsible, and resilient global halal economy, while reducing waste, promoting responsible production and consumption, and strengthening long-term economic and social well-being.

Keywords: Halal Economy, Halal Certification, Consumer Protection, Sustainability, Circular Economy, Halal Value Chains, Legal Regulation, Consumer Rights, Certification Bodies, Traceability

(O-50) BEYOND HALAL CERTIFICATION: RECONSTRUCTING ṬAYYIB FOR SUSTAINABLE HALAL FOOD GOVERNANCE IN INDONESIA

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Abstract

Indonesia's expanding halal assurance system has strengthened legal certainty and product integrity within the halal food ecosystem. Compliance with halal requirements, however, does not necessarily address avoidable waste and inefficient resource use arising from production, packaging, consumption, and disposal. Recent scholarship has increasingly connected halal–ṭayyib with sustainability, circular economy, and responsible consumption. The place of environmental responsibility within the juridical boundaries of halal governance remains less clearly defined, particularly when contemporary sustainability concerns are related to Qur'anic concepts whose earlier meanings developed in different contexts. This study examines the normative function of ṭayyib within the wider Qur'anic ethics of consumption and considers its implications for waste prevention and sustainable halal food governance in Indonesia. The analysis reads Qur'anic passages on halal–ṭayyib, isrāf, and tabdhīr intratextually and follows their interpretation across selected classical and modern tafsīr. These textual findings are then examined alongside Indonesia's current halal assurance regulations to determine how far existing regulatory concerns extend to resource use and waste prevention. Indonesia's halal assurance framework already addresses process integrity, hygiene, packaging, distribution, and certain forms of waste handling. Its regulatory logic remains primarily directed toward safeguarding halal integrity, while waste prevention and resource efficiency occupy a more limited position. The Qur'anic and exegetical evidence also does not support a direct equivalence between ṭayyib and sustainability. Ṭayyib primarily provides an ethical orientation toward wholesomeness, benefit, and the avoidance of harm. Qur'anic prohibitions of isrāf and tabdhīr offer firmer grounds for restraint and for extending the ethics of proper resource use to contemporary problems of food and material waste. Read together, these concepts support an understanding of halal governance that begins with juridical integrity and extends to wholesomeness, resource responsibility, and sustainability. This approach treats waste prevention and resource efficiency as complementary dimensions of halal governance rather than additional criteria for determining halal status. For Indonesia's halal food ecosystem, it provides a normative basis for placing waste prevention earlier in production and consumption processes while preserving the juridical boundaries of halal certification

Keywords: halal certification, ṭayyib, sustainable halal, waste prevention, Indonesia

(O-51) HALAL-BY-DESIGN TROUT AQUACULTURE: INTEGRATING HALAL FEED, SUSTAINABLE NUTRITION, FISH HEALTH, TRACEABILITY AND VALUE-CHAIN DEVELOPMENT IN JAMMU AND KASHMIR

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Abstract

Trout aquaculture offers opportunities for sustainable food production and rural livelihood development in Jammu and Kashmir, India, where favourable cold-water resources support rainbow trout farming. Integrating this sector into halal food value chains, however, requires a systematic approach to halal integrity extending beyond the harvested fish to feed ingredients, production practices, processing and product traceability. This paper proposes a standards-informed halal-by-design framework tailored to the region's trout aquaculture sector.

The framework is developed through a structured review of scientific literature on halal feed, aquaculture nutrition, fish health, food safety and supply-chain traceability, combined with a comparative analysis of relevant halal standards and guidelines. Particular attention is given to OIC/SMIIC 23:2022, Feeding Stuffs for Halal Animals – General Requirements, alongside applicable halal food and supply-chain standards and Codex Alimentarius guidelines on the use of the term halal. The analysis focuses on feed-ingredient provenance, animal- and microbial-derived ingredients and additives, supplier verification, feed handling, fish health management, veterinary inputs, hygienic processing and traceability. It also examines the applicability of existing provisions to trout farming and identifies areas requiring fish-specific interpretation and further validation.

The framework's principal contribution is the integration of halal feed assurance with responsible aquaculture management, farm-to-market documentation and value-chain development within a single operational model. It identifies potential control points, documentation requirements and stakeholder responsibilities from feed sourcing to final product distribution. Digital traceability is proposed as a means of linking production and processing records with product identity and relevant certification documentation.

Potential benefits include improved supply-chain transparency, opportunities for value addition and stronger market linkages for regional trout producers. These outcomes remain to be empirically evaluated. The proposed framework therefore provides a foundation for future stakeholder consultation, pilot implementation and assessment using indicators such as feed-ingredient verification, traceability performance, implementation costs, employment and product value addition. It offers a context-specific approach to exploring the contribution of trout aquaculture to the developing halal food economy while recognising the need for competent halal oversight and evidence-based validation.

Keywords: Halal aquaculture; rainbow trout; Jammu and Kashmir; OIC/SMIIC 23:2022; halal feed assurance; sustainable nutrition; fish health; traceability; value-chain development

(O-52) HALAL LIVING AND A SPORTS CAREER

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Abstract

Is it possible to pursue a sporting career within the bounds of halal (permissible in Islam)? This study was conducted to answer this question. Specifically, it aims to raise awareness among families and young people about how to shape their sporting career aspirations while remaining within the framework of halal.

Within the halal framework, a sporting career consists of several stages. The first stage: whether the sport's dress code is suitable for a halal sporting career. The second stage: whether the movements performed in the sport are designed to showcase body contours. The third stage: the rate of use of ergogenic aids (such as anabolic steroids, doping agents, and stimulants) due to high-performance expectations in the sport. The fourth stage: the views of the relevant sports community regarding halal lifestyle culture.

Young people and their families considering a sports career in line with halal living are advised to plan their careers by paying attention to the stages mentioned above. However, for a successful sports career, individuals must first possess the physical characteristics of the relevant sport. The physical requirements of each sport vary with the sport. For example, being tall can generally be considered an advantage in volleyball and basketball.

The verse in the Quran, "Lekum dînukum ve liye dîn" (Your religion is for you, and my religion is for me), is found in Surah Al-Kafirun, verse 109. Based on this verse, questioning the life choices of those who practice these sports is absolutely out of the question. In accordance with Article 24 of the Constitution of the Republic of Türkiye, which states, "Everyone has the freedom of conscience, religious belief and opinion," no one has any prejudice against anyone's religious beliefs and opinions. The aim of this study is to offer ideas on this subject to our young people and their families who wish to live their lives within the bounds of halal (permissible).

In recent times, the compatibility of certain negative behaviors observed at the Olympics and World Championships with living a halal life has been debated. Following the distribution of 150,000 condoms at the 2020 Tokyo Olympics despite the ban on sexual intercourse due to the COVID-19 pandemic, 300,000 condoms were supplied to athletes at the 2024 Paris Olympics (www.olympics.com).

The secular, faithless lifestyle that has swept the world is most often imposed on humanity through practices in sports. By emphasizing elements such as sporting success, medals, and championships, the aim is to legitimize a secular, faithless way of life that lies beneath them.

In conclusion, the question of whether it is possible to pursue a sporting career within the framework of halal living has been answered with a partial affirmative effect. The relevant sports federations have very limited regulations regarding religious lifestyles. However, it is observed that the behavior of Muslim footballers in the top leagues of professional football, adhering to Islamic principles, has fostered sympathy towards Islam worldwide.

Keywords: Halal Living, Sporting Career, Professional Sports

(O-53) A THEORETICAL ANALYSIS OF THE RELATIONSHIP BETWEEN HALAL AWARENESS AND SOCIAL SUSTAINABILITY

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Abstract

Halal awareness is typically operationalized as consumer knowledge of halal standards and certification, which overlooks the effective and behavioral processes through which awareness develops and acquires social meaning. This conceptual paper defines halal awareness as a multidimensional, developmental consumer competence comprising cognitive (knowledge of standards and certification), affective (trust, value attachment, satisfaction), and behavioral (inquiry, adoption, readiness, action) dimensions that evolve over time. Social sustainability is operationalized through four outcomes: social trust (interpersonal and institutional), social cohesion (cross-group relations and belonging), cultural identity preservation, and societal well-being. Each is linked to established indicators that future studies can measure. The framework integrates three theories with distinct roles. Value-Belief-Norm Theory explains how awareness becomes internalized as personal norms; the Innovation-Decision Process Model explains how awareness progresses from knowledge to implementation and confirmation; and Expectation-Confirmation Theory explains whether engagement is sustained through satisfaction. Drawing on a structured narrative review of [databases, period, search terms, inclusion/exclusion criteria, synthesis procedure], the paper proposes that halal awareness directly strengthens personal norms and trust in certification (P1) and indirectly shapes societal outcomes through satisfaction and community-level norm diffusion as mediators (P2–P3). These relationships are moderated by religious and cultural diversity, certification transparency, and institutional credibility (P4). The paper also considers that halal awareness may reinforce in-group cohesion without necessarily fostering inclusivity across diverse communities. Unlike existing halal awareness and ethical consumption models, which focus largely on individual purchase intention, the framework links individual awareness to societal outcomes. Implications are outlined for policymakers, certification bodies, industry stakeholders, and future empirical researchers.

Keywords: Halal awareness, social sustainability, innovation-decision process, value-belief-norm theory, conceptual model

(O-54) METABOLOMICS FOR SUSTAINABLE HALAL FOOD SYSTEMS: INTEGRATING AUTHENTICATION, FOOD SAFETY, AND FOOD WASTE REDUCTION

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Abstract

The growing global demand for halal food has increased the need for analytical approaches that can ensure not only halal authenticity but also food safety, quality, and sustainability. Conventional halal authentication methods, including DNA-based and immunological techniques, are effective for detecting specific prohibited or adulterant materials; however, they may provide limited information on the broader chemical changes associated with food processing, deterioration, and storage. Metabolomics offers a comprehensive approach to characterizing low molecular weight metabolites and metabolic fingerprints, providing new opportunities for the development of sustainable halal food systems. This paper presents a narrative synthesis of selected literature on metabolomics applications in three interconnected domains: halal authentication, food safety, and food waste reduction. Metabolic fingerprinting combined with chemometric and machine-learning approaches can support species discrimination, adulteration detection, and identification of potential biomarkers for halal authentication. Beyond authenticity, metabolomic changes associated with microbial activity, oxidation, degradation, and other biochemical processes may provide valuable indicators of food safety and quality. Additionally, monitoring dynamic metabolic changes during storage could facilitate the discovery of freshness biomarkers and the development of predictive models for remaining shelf life, thereby supporting more accurate food-quality decisions and reducing unnecessary food disposal. An integrated framework combining metabolomics, advanced data analytics, and predictive modeling is therefore proposed to connect halal integrity with food safety and sustainable resource utilization. Future advances in standardized analytical protocols, halal-specific metabolite databases, biomarker validation, and artificial intelligence could accelerate the translation of metabolomics from laboratory-based analysis toward intelligent decision-support systems for sustainable halal food supply chains.

Keywords: metabolomics, halal authentication, food safety, food waste, sustainability

Introduction

The global demand for halal food has expanded substantially, driven by the growing Muslim population, increasing consumer awareness, and globalization of halal food supply chains (Musfirah et al., 2025). Halal food is increasingly associated not only with religious compliance but also with authenticity, safety, quality, traceability, and responsible production. These expectations align with sustainable food systems, which aim to ensure food security and nutrition while reducing environmental impacts and resource losses.

Maintaining halal integrity remains challenging because modern food supply chains involve complex ingredients, extensive processing, multiple suppliers, and international distribution. Adulteration, substitution of animal-derived ingredients, cross-contamination, and uncertain ingredient origins may compromise halal authenticity. Conventional analytical methods, including polymerase chain reaction (PCR), immunoassays, spectroscopy, and targeted chemical analysis, are important for halal verification but generally focus on predefined species, compounds, or markers (Rohman et al., 2025).

Food safety and food waste are additional concerns. Microbial contamination, oxidation, chemical deterioration, and inappropriate storage can alter food composition and reduce safety and quality. Meanwhile, uncertainty regarding freshness and remaining shelf life may contribute to unnecessary food disposal and inefficient use of raw materials, water, energy, and other resources (Su et al., 2024).

Metabolomics provides comprehensive characterization of low-molecular-weight metabolites and can reveal biochemical changes associated with food origin, processing, adulteration, deterioration, and storage. Analytical platforms such as liquid chromatography–mass spectrometry (LC–MS), gas chromatography–mass spectrometry (GC–MS), and nuclear magnetic resonance (NMR), combined with chemometrics and machine learning (ML), can generate metabolic fingerprints and identify potential biomarkers (Putri et al., 2025).

This paper discusses metabolomics as an integrated analytical framework for sustainable halal food systems, focusing on halal authentication, food safety, freshness assessment, food waste reduction, and the development of predictive and data-driven halal food management.

Methodology

This paper adopts a focused narrative literature review to synthesize published evidence on metabolomics in halal authentication, food safety, freshness assessment, and food waste reduction. The review is organized around these application domains and considers how their findings may be connected within sustainable halal food systems.

To make the review process transparent and reproducible, relevant literature should be searched in multidisciplinary and subject-specific databases such as Scopus, Science Direct, PubMed, and Google Scholar. where available (Atiaa et al., 2025). Search terms may combine “metabolomics” or “metabolic profiling” with “halal authentication,” “food authenticity,” “food safety,” “food spoilage,” “freshness,” “remaining shelf life,” and “food waste.” The exact databases, search dates, search strings, and number of records screened should be reported according to the searches performed.

Studies are relevant when they report empirical applications of metabolomics to food authentication, contamination or hazard assessment, freshness or deterioration monitoring, or shelf-life prediction. Review articles may also be included to establish context and identify relevant primary studies.

Studies without a clear connection to food systems or to one of the review domains are less directly relevant. As this paper is a narrative synthesis rather than a systematic review, it does not claim exhaustive coverage or formal risk-of-bias assessment; conclusions should be interpreted as a synthesis of selected literature.

For each selected study, the synthesis considers the food matrix, analytical platform, targeted or untargeted design, main findings, validation approach, and reported limitations. This structure supports comparison across application areas and distinguishes demonstrated findings from proposed future applications.

3. Metabolomics as an Analytical Platform for Halal Food Systems

Metabolomics focuses on the comprehensive characterization of metabolites such as amino acids, organic acids, fatty acids, lipids, sugars, nucleotides, and phenolic compounds. Because metabolite profiles are influenced by biological origin, processing, environmental conditions, storage, and deterioration, they provide characteristic metabolic fingerprints of food (Putri et al., 2025). Metabolomics can be divided into targeted and untargeted approaches (Hew et al., 2024). Targeted metabolomics measures predefined compounds and is appropriate when specific biomarkers are known, whereas untargeted metabolomics detects a broad range of metabolites and is particularly valuable for exploratory studies and biomarker discovery. Following validation, selected biomarkers can subsequently be transferred into targeted methods for routine analysis. The potential applications of metabolomics in sustainable halal food systems, encompassing halal authentication, food safety and quality, and food waste reduction, are summarized in Figure 2.1.

LC–MS, GC–MS, and NMR are major analytical platforms. Principal component analysis (PCA) can reveal natural clustering and outliers, while supervised approaches such as partial least squares discriminant analysis (PLS-DA) identify discriminatory features. ML can further develop classification and predictive models. Within halal food systems, metabolomics complements DNA-, protein-, and targeted chemical-based approaches because metabolic fingerprints may simultaneously provide information related to authentication, safety, freshness, and shelf life.

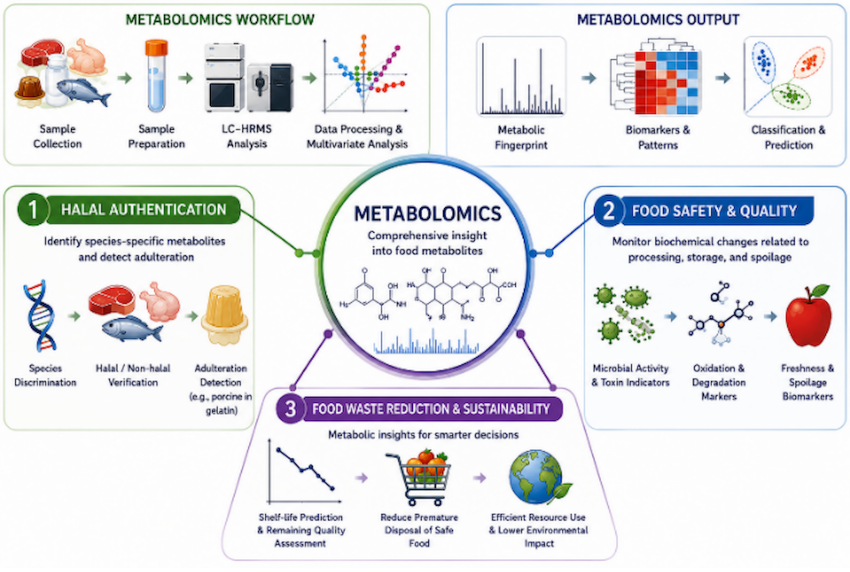

Figure 3.1. Metabolomics for Sustainable Halal Food Systems

4. **Metabolomics for Halal Authentication**

Halal authentication ensures that foods and ingredients comply with Islamic dietary requirements. Verification becomes difficult when animal-derived materials such as meat, gelatin, fats, and food additives undergo extensive processing or when products contain ingredients from multiple biological sources. In meat products, halal authentication may also involve verifying the slaughtering status, as differences between halal-slaughtered and non-halal or improperly slaughtered animals can potentially influence postmortem biochemical and metabolic profiles (Maritha et al., 2025). Metabolomics provides a complementary strategy by characterizing broad chemical profiles associated with biological origin, species, ingredients, slaughtering conditions, and processing. Untargeted analysis can simultaneously detect numerous amino acids, peptides, lipids, fatty acids, nucleotides, and other metabolites. PCA, PLS-DA, and related chemometric methods can subsequently identify characteristic patterns and discriminatory features among authenticated sample group (Windarsih et al., 2024).

This approach is particularly promising for highly processed animal-derived ingredients such as gelatin, where metabolic fingerprints can provide information on biological origin and adulteration (Harlina et al., 2024). Significant and reproducible metabolites may serve as candidate biomarkers but require structural confirmation and validation using independent samples from diverse origins and processing conditions. ML models trained with authenticated reference samples could classify unknown samples. A halal-specific metabolite database containing authenticated fingerprints, validated biomarkers, accurate masses, retention times, and MS/MS spectra could further support authentication. Nevertheless, metabolomics should complement established DNA-based, proteomic, immunological, and targeted analytical techniques.

5. **Metabolomics for Food Safety**

Food safety is an essential component of halalan tayyiban (Idris et al., 2022). Food may be affected by pathogenic microorganisms, toxins, residues, environmental contaminants, oxidation, and undesirable compounds generated during processing or storage. Microbial growth, enzymatic activity, oxidation, and chemical degradation alter multiple metabolites simultaneously. Changes in organic acids, alcohols, aldehydes, ketones, amines, lipids, and other metabolites can therefore provide molecular information regarding food deterioration, particularly in perishable products such as meat, poultry, seafood, and dairy products (Hew et al., 2024).

Metabolomics may also support the detection of foodborne microbial contamination through metabolic signatures associated with pathogen growth. For example, metabolite biomarkers have been identified *for Salmonella Enteritidis* contamination in chicken meat (Chen et al., 2023), while metabolic fingerprinting combined with machine learning has shown potential for microbial hazard classification. Beyond pathogens, metabolomic profiles may provide complementary information on chemical and fungal hazards, including metabolic signatures associated with mycotoxin production (Mandal et al., 2024).

Rather than relying on a single compound, panels of metabolites may provide more representative indicators of microbial or chemical contamination. However, candidate safety-related biomarkers must be validated against established microbiological, physicochemical, or toxicological criteria. Validation

across independent food matrices, microbial strains, and contamination levels is also important before routine application. Such models could eventually help identify food safety-related metabolic patterns and support monitoring throughout production, transportation, storage, and distribution (Feng et al., 2024).

6. **Metabolomics for Food Waste Reduction**

During storage, enzymatic reactions, microbial activity, lipid oxidation, protein degradation, and nucleotide breakdown progressively alter food metabolite profiles. These changes may involve organic acids, biogenic amines, nucleotides, amino acids, lipid oxidation products, and volatile metabolites, providing potential molecular indicators of freshness and deterioration (Guo et al., 2025; Ju et al., 2025). Metabolomics can characterize these changes and identify metabolic fingerprints associated with different stages of freshness. A proposed metabolomics-based framework for predicting food freshness and remaining shelf life is presented in Figure 5.1.

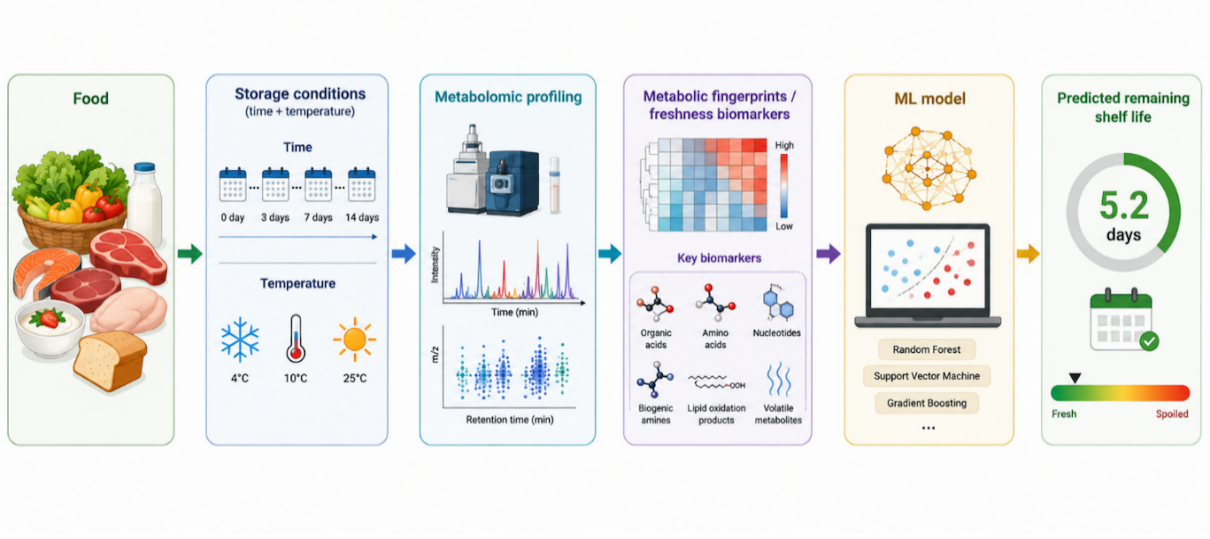

Figure 6.1. Metabolomics-Based framework for predicting food freshness and remaining shelf life

Potential biomarkers should be identified using foods stored under controlled times and temperatures and subsequently validated against conventional indicators such as microbial counts, pH, oxidation indices, texture, color, and sensory characteristics. Potential metabolite biomarkers associated with food freshness and deterioration are illustrated in Figure 5.2.

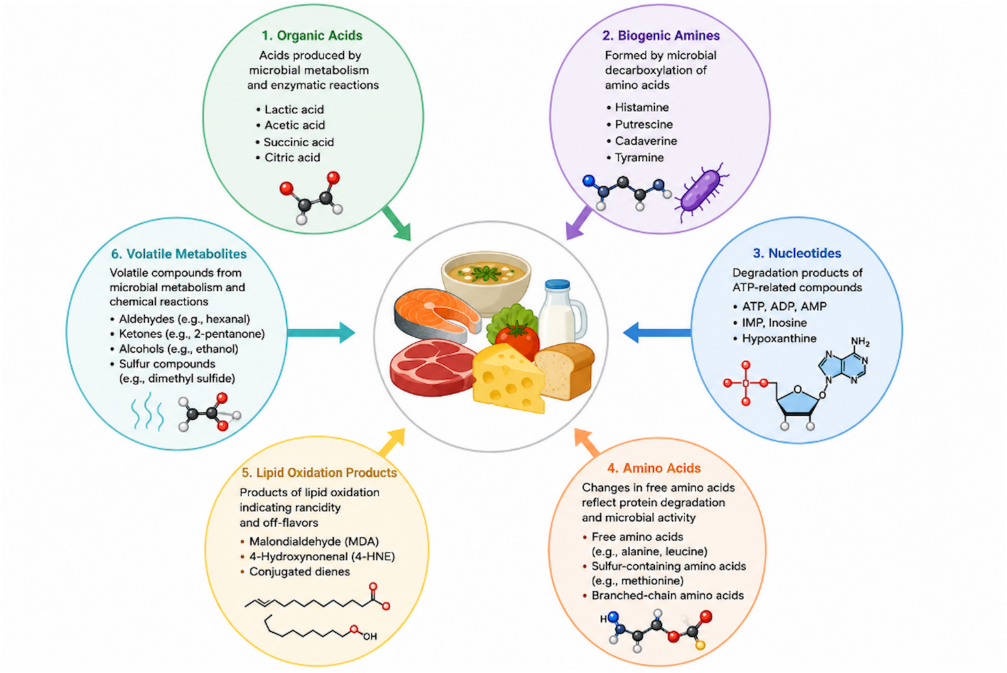

Figure 6.2. Potential biomarkers of food freshness

Beyond distinguishing fresh and deteriorated foods, metabolomics may support remaining shelf-life (RSL) prediction by integrating metabolomic profiles with processing, packaging, transportation, temperature exposure, storage history, and conventional quality measurements. Validated predictive models could estimate food deterioration and support food waste reduction. Products with shorter predicted RSL could be prioritized for distribution, sale, processing, or consumption, while those with longer RSL could be allocated to longer storage or transportation. However, metabolomics-based predictions should not extend safety-related expiration limits without microbiological, toxicological, and regulatory validation.

7. Integrated Framework for Sustainable Halal Food Systems

The proposed framework's main contribution is the integration of three interconnected domains: halal authentication, food safety, and freshness and remaining shelf-life assessment, which are often studied separately. Rather than relying on a universal set of biomarkers, it combines validated metabolomic features with sample provenance, processing history, storage conditions, and conventional analytical results. Implementation involves establishing authenticated reference samples and standardized analytical workflows, validating domain-specific biomarkers, integrating metabolomic data into a halal-specific database, and externally validating predictive models using independent food samples and supply-chain conditions. This approach could support evidence-based decision-making while ensuring that halal compliance and food safety assessments remain subject to appropriate standards and verification.

The broader potential of metabolomics lies in integrating authentication, safety, freshness, and sustainability within a common analytical framework. The same metabolomic dataset may contain species- or origin-related biomarkers for authentication, deterioration-related biomarkers for food safety, and storage-dependent biomarkers for freshness and shelf-life assessment (Mandal et al., 2024).

The applications of metabolomics in halal authentication, food safety, and food waste reduction, together with the analytical methods and key findings, are summarized in Table 7.1.

A halal metabolomics database could integrate authenticated samples, metabolite information, processing, and storage data. Machine learning could support authentication, safety assessment, freshness evaluation, and shelf-life prediction (Shawky et al., 2025). Integration with sensors, traceability, and supply-chain data could strengthen decision-making, support FEFO strategies, reduce food fraud and waste, and enable predictive halal food management.

Table 7.1. Selected Applications of Metabolomics in Sustainable Halal Food Systems

Application Area	**Food/Product**	**Analytical Method**	**Key Findings**	**References**
Halal Authentication	Gelatin	UHPLC-HRMS, Untargeted	Fifteen potential metabolites were identified by PLS-DA for the halal authentication of gelatin	(Harlina et al., 2024)
	Gelatin	LC–QTOF–MS/MS, Untargeted	PCA clearly distinguished between bovine and porcine gelatin.	(Mahamud et al., 2025)
	Beef meat	LC-HRMS, Untargeted	All raw beef meat samples containing non-halal meats could be differentiated from authentic raw beef meat.	(Windarsih et al., 2024)
	Poultry meat, halal slaughtered	LC–QTOF–MS/MS, Untargeted	The key metabolites, xanthine was found to be upregulated, while phytosphingosine and C6-ceramide were found to be downregulated in dead chickens compared to slaughtered chickens.	(Akhtar et al., 2025)
	Beef meatball	UHPLC–Orbitrap HRMS, Untargeted	Successfully detected dog meat adulteration in beef meatballs at levels as low as 0.1% (w/w) using non-targeted LC–HRMS metabolomics and chemometrics.	(Windarsih et al., 2023)
	Chicken meat, slaughtered	UHPLC-HRMS, Untargeted	Metabolite profiles clearly differentiated halal, non-halal, and shubha-halal chicken meat, with 13 potential biomarkers identified for authentication.	(Maritha et al., 2024)
	Processed meat	UHPLC-HRMS, Untargeted	Beef and pork products were clearly differentiated, with 15 potential metabolites identified as biomarkers for halal authentication.	(Musfiroh et al., 2026)
Food Safety	Chicken meat	UPLC-Q Orbitrap MS/MS, Untargeted & targeted	Five biomarkers were identified for *Salmonella Enteritidis* contamination in chicken.	(Chen et al., 2023)
	Fish (Tuna)	NMR, Untargeted	The accumulation of polychlorinated biphenyls and organochlorine pesticides was associated with sex-specific metabolic changes in bluefin tuna, particularly in energy, amino acid, and lipid metabolism.	(Cappello et al., 2018)
	Fruit-associated *Penicillium expansum*	UPLC-Q- TOF-MS, Untargeted	Metabolic signatures differentiated high- and low-patulin-producing strains, with potential biomarkers identified for patulin production.	Liu et al., 2025

Food Waste Reduction	Goose meat	LC-ESI-QTRAP-MS/MS, Untargeted	Identified 30 candidate biomarkers associated with goose meat deterioration, with a quality deterioration threshold at day 5 of refrigerated storage.	(Gao et al., 2025)
	Vegetables	UHPLC-Q-Exactive Orbitrap MS, GC–MS, UPLC-TQ MS, Untargeted & targeted	Storage-dependent metabolic changes were identified in four refrigerated vegetables, with selected metabolites proposed as potential freshness indicators.	(Meng et al., 2024)
	Salmon	UHPLC-QTRAP/MS, Targeted	Alanine, inosine, and histidine were identified as potential biomarkers of salmon freshness.	(Lu et al., 2024)

8. Challenges and Future Perspectives

A key research priority is to establish standardized reference materials and reporting practices across laboratories, including sample provenance, analytical procedures, quality-control performance, metabolite identification, and model validation, to improve reproducibility and comparability. Implementation should follow a staged validation process, assessing model performance, acceptable error rates, and cost-effectiveness under representative product and supply-chain conditions. For food-waste reduction, predicted remaining shelf life may support stock rotation and distribution decisions but should not override legal date marking or validated food-safety controls.

Several challenges must be addressed before routine implementation. Differences in sample collection, extraction, storage, chromatographic conditions, mass spectrometric parameters, and data-processing methods can affect reproducibility. Metabolite identification remains another bottleneck in untargeted metabolomics, and statistically significant features should not automatically be regarded as reliable biomarkers.

Candidate biomarkers require structural confirmation and validation using independent and diverse samples. Large representative datasets are also required for ML because small sample sizes combined with high-dimensional data increase the risk of overfitting. External validation, generalizability, and model interpretability are therefore essential.

Cost and accessibility remain limitations because high-resolution LC–MS and NMR require expensive instrumentation and specialized expertise. Validated biomarkers could ultimately be translated into targeted assays, biosensors, spectroscopy-based methods, or portable technologies (Hew et al., 2024). Future systems may integrate metabolomics with artificial intelligence, sensors, genomics, proteomics, microbiological information, digital traceability, and supply-chain data.

Conclusion

Metabolomics offers a promising analytical platform for sustainable halal food systems by providing molecular information related to food origin, authenticity, safety, freshness, and deterioration. Its integration with chemometrics, machine learning, storage history, and conventional food-quality measurements may enable the transition from descriptive analysis toward predictive food assessment.

Successful implementation will require standardized workflows, robust biomarker validation, representative reference samples, halal-specific metabolomic databases, and externally validated predictive models. Translating biomarkers discovered through high-resolution metabolomics into

simpler, rapid, and cost-effective methods will also be important for routine applications. By integrating halal authentication, food safety, freshness assessment, and food waste reduction within a unified analytical framework, metabolomics could contribute to halal food systems that are compliant safe, traceable, resource-efficient, intelligent, and sustainable.

The central contribution of this review is to connect domain-specific metabolomic evidence within a shared decision-support framework while recognizing that authentication, food-safety assessment, and shelf-life prediction have distinct validation requirements.

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(O-55) THE HALAL FORM OF SECULARIZATION: SANITIZED CONSERVATISM FROM GATED COMMUNITIES TO HALAL RESORTS

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Abstract

This paper develops the notion of sanitized conservatism to examine the changing relationship between religiosity, class, consumption, and space among Turkey's affluent and upwardly mobile conservative social groups. The argument does not equate socioeconomic mobility with the decline of religious belief, nor does it assume that consumer participation necessarily produces secular individuals. Instead, it asks whether particular dimensions of religious life can become reorganized through privatized, market-mediated, class-homogeneous, and carefully controlled environments while religious identification remains strong. Drawing on scholarship on secularization, Islamic middle-class formation, gated communities, veiling fashion, consumer culture, neoliberal urbanism, and halal tourism, the study identifies a movement from direct exposure to morally and socially heterogeneous environments toward curated spaces in which the perceived inconveniences, uncertainties, and moral risks of modern urban life are filtered without requiring withdrawal from modern consumption itself.

The concept of sanitized conservatism refers to a class-conditioned form of religious conservatism in which moral boundaries are preserved while exposure to socioeconomic deprivation, cultural difference, moral uncertainty, bodily discomfort, and some of the ascetic or solidaristic demands associated with communal religious life is increasingly mediated through private spaces, professional organizations, and market services. Islamic gated communities and halal resorts provide two particularly revealing institutional forms. The former can combine religiously congenial surroundings with security, exclusivity, infrastructure, and class homogeneity; the latter makes possible participation in modern leisure consumption while selectively excluding alcohol, non-halal food, unwanted forms of gender mixing, or other practices regarded as religiously problematic.

The study proposes that this process can be understood as a "halal form of secularization" only in a qualified sense. It is not secularization as the disappearance of religion. Rather, it involves the partial transformation of religion from an embedded communal order into an increasingly curated lifestyle whose compatibility with comfort, distinction, privacy, and consumption is institutionally produced. The study further develops the concepts of moral filtration, class insulation, halalization of luxury, and the ummah paradox, and concludes by outlining empirically falsifiable propositions for future research.

Keywords: sanitized conservatism; secularization; halal consumption; gated communities, halal tourism, Islamic middle class, neoliberalism, Turkey, class, religiosity.

(O-56) GREENING THE HALAL ECONOMY: TRANSLATING CORPORATE ENVIRONMENTAL STRATEGY INTO SUSTAINABLE PERFORMANCE THROUGH GREEN BEHAVIORAL INTENTIONS

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Abstract

The growing global emphasis on sustainability is reshaping the expectations placed on the halal economy, extending organizational responsibility beyond conventional halal compliance toward environmentally responsible production, resource efficiency, and sustainable value creation. Despite this transition, limited empirical attention has been devoted to understanding how environmental strategies adopted at the corporate level translate into sustainable performance within manufacturing organizations operating in an emerging halal economy. Addressing this gap, this study examines the impact of corporate environmental strategy on sustainable performance and investigates green behavioral intentions as the underlying mechanism through which strategic environmental commitments are translated into organizational outcomes. The study adopts a quantitative, cross-sectional, survey-based research design in the Pakistani manufacturing sector. Using purposive sampling, data will be collected from approximately 500 respondents working in manufacturing organizations. The proposed relationships will be examined through Partial Least Squares Structural Equation Modeling (PLS-SEM), including assessment of the measurement model, structural relationships, and the mediating effect of green behavioral intentions. The study anticipates that corporate environmental strategy will positively influence sustainable performance both directly and indirectly by strengthening employees' green behavioral intentions.

By connecting corporate-level environmental strategy with employee-level behavioral intentions, the study seeks to explain the organizational mechanism through which environmental commitments can generate sustainable outcomes. In the context of the halal economy, the findings are expected to demonstrate how manufacturing organizations can progress beyond compliance-oriented approaches toward environmentally responsible production, efficient resource utilization, waste reduction, and long-term sustainable growth. The study consequently extends the application of NRBV to the emerging discourse on sustainable halal economies and offers practical implications for manufacturers, policymakers, and halal industry stakeholders seeking to align environmental strategy with the broader objectives of sustainable and responsible halal production.

Keywords: Halal Economy, Corporate Environmental Strategy, Sustainable Performance, Green Behavioral Intentions, Natural Resource-Based View, Manufacturing Industry, Pakistan

(O-57) MEASURING HALAL-RELATED CONSUMER BURDEN: A DUAL-COMPARATOR FRAMEWORK AND AN EXPLORATORY UK POULTRY ILLUSTRATION

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Abstract

Halal purchasing in Muslim-minority markets may entail search, access and verification costs in addition to product prices, but retail price observations alone cannot establish the scale of these broader burdens. This conceptual and methodological study develops a dual-comparator framework for measuring halal-related consumer burden and presents an exploratory price-based illustration using six poultry product listings from one United Kingdom retailer. Drawing on a structured integrative synthesis of 54 scholarly and authoritative sources, the framework distinguishes the closest functionally comparable conventional alternative from the least burdensome religiously acceptable and practically available option under a specified consumer acceptance rule. It differentiates displayed or adjusted price, narrow monetary burden and total accounting burden, while specifying matching, quality-balance, eligibility, availability and evidential safeguards. The illustration uses four frozen chicken-breast listings and two fresh whole-chicken listings observed principally on 27 July 2026. In one frozen-breast comparison, identical displayed prices of £7.00 per kilogram yielded a 12.5% difference when expressed per kilogram of declared chicken content; this is a partial compositional sensitivity calculation, not a fully quality-adjusted halal premium. Clubcard promotions reversed the sign of selected price differentials, while displayed stock restrictions affected eligibility for the observed price-based feasible comparator. The single-retailer, single-date illustration cannot estimate representative halal-related price differentials, measure household-level search or access burdens, or validate the full framework. The study contributes a transparent, metric-specific protocol and a deliberately bounded demonstration of selected price and comparator procedures, providing a basis for future multi-retailer, longitudinal and user-level research.

Keywords: halal-related consumer burden; dual-comparator framework; Muslim-minority markets; constrained choice; exploratory poultry price illustration

I. INTRODUCTION

1.1 Background and policy problem

The Islamic economy includes halal food, medicines, cosmetics, modest fashion, Muslim-friendly tourism, media and entertainment, and Islamic banking (DinarStandard, 2026). Halal assurance and Shariah governance can involve certification, segregation, monitoring, specialist labour, traceability, restricted supply chains, legal structuring and documentation (Tieman, 2011; Tieman et al., 2012; Soon et al., 2017; Khan et al., 2018). These processes may create genuine provider costs and consumer

value. Nevertheless, neither a halal label nor a retail price difference establishes the source of the price, the incidence of the costs or any resulting welfare consequence. This study addresses the measurement problem rather than presuming that halal-labelled products command a generalisable premium.

The measurement problem becomes more complex when religious compliance is a binding requirement rather than an optional lifestyle preference. A Muslim household may reject a conventional substitute as religiously unacceptable even when it remains the closest economic benchmark. The household's observed expenditure may therefore reflect a choice made within a restricted feasible set rather than an unconstrained willingness to pay. Similar forms of constrained choice can be found in halal food consumption in minority markets, Islamic home finance and Muslim-friendly tourism (Bonne et al., 2007; Bonne & Verbeke, 2008; El-Gamal, 2006; Battour & Ismail, 2016).

This problem also shares features with other forms of constrained consumption. Research on consideration sets indicates that consumers do not necessarily evaluate every option available in the market. Poverty-premium research similarly demonstrates that access, liquidity, information and market structure can make an apparently cheaper option unavailable in practice or more burdensome for a low-income household (Caplovitz, 1963; Roberts & Lattin, 1991). These parallels do not suggest that the halal-related differential is identical to either a consideration-set phenomenon or a poverty premium. Rather, they help explain why the options consumers can realistically choose may differ from the most relevant economic benchmark.

The concern is broader than whether a halal-labelled product carries a higher shelf price. Depending on the location, consumer and product category, options that satisfy an individual's religious acceptance rule may be harder to locate, verify or obtain than conventional alternatives. Search, travel, delivery, verification and stock constraints could therefore affect the consumer's effective expenditure even where listed prices are equal or lower. The scale and direction of any such burden require user- and location-specific evidence; they cannot be inferred from a small retailer-price snapshot. This motivates a measurement protocol that separates the closest conventional benchmark from the least burdensome acceptable option that is practically available.

Even a limited shelf-price comparison requires care. Pack size, product content, freshness, origin, welfare standards, brand and delivery conditions may differ; in other sectors, service quality, legal protection, liquidity and risk allocation may matter. Without adequate matching or adjustment (Lancaster, 1966; Rosen, 1974; Zeithaml, 1988), an observed gap may reflect ordinary product or contract attributes rather than halal-related assurance. Equally, indiscriminate adjustment could remove valuable assurance or broader tayyib characteristics. The proposed procedure therefore records mandatory attributes, balanced characteristics, unresolved differences and the evidential limits of any explanation.

1.2 Research gap and positioning

Existing studies explain several key dimensions of this challenge. Studies relating to the willingness to pay recognise religiosity, trust, certification, perceived quality, subjective norms and the value of logistics services as important influences on consumer purchasing behaviour (Ajzen, 1991; Shah Alam & Mohamed Sayuti, 2011; Ahmed et al., 2019; Fathi et al., 2016; Iranmanesh et al., 2019; Fauzi,

2023). Studies on halal assurance and logistics have documented the required resources for certification, traceability, segregation and supplier management (Ab Talib et al., 2015; Ali et al., 2017; Annabi & Ibidapo-Obe, 2017). The Islamic finance literature further explores Shariah governance, legal structuring, ownership, liquidity, screening, and risk allocation (Vogel & Hayes, 1998; Usmani, 2002; El-Gamal, 2006; Iqbal & Mirakhor, 2011).

These literatures illuminate important parts of the problem, yet the sources synthesised for this study do not yield a single operational protocol that simultaneously specifies a functionally comparable conventional benchmark, a user-specific religiously screened feasible set, metric-specific consumer burden, distinct provider-cost explanations, and explicit reporting limits. The research gap is therefore one of integrated measurement design, not proof that each component has been neglected or that a new economic law is required.

The contribution is methodological rather than a novel algebraic identity. The decomposition follows by adding and subtracting the burden of a metric-specific intermediate comparator. Its substantive value depends on how the comparators and metrics are defined, matched and observed. The proposed protocol therefore uses common-support and stopping rules, quality-balance checks, controls against double counting, narrow proxy labels and separate grades for source quality and inferential quality. The small poultry illustration demonstrates selected procedures; it does not constitute a validation study.

1.3 Research objectives

The study pursues seven objectives:

1. To define a neutral, signed halal-related burden differential that may be positive, zero or negative, depending on the specified measure and context.
2. To develop a dual-comparator framework distinguishing the closest functionally comparable conventional option from the least burdensome religiously acceptable and practically available option under a declared user rule.
3. To specify separate procedures for price, narrow monetary burden and total accounting burden, including metric-consistent decomposition into focal-choice and religiously screened feasible-set differentials.
4. To establish comparator-construction safeguards covering mandatory attributes, quality balance, residual distance, tie resolution, common support and stopping conditions.
5. To distinguish consumer-side burden from ordinary product attributes, provider costs and market mark-ups, and to prevent the double counting of burden components.
6. To establish reporting standards for evidence quality, comparability, uncertainty and the separation of numerical measurement from Shariah, fairness, harm or policy judgements.
7. To demonstrate selected retail-price and comparator-selection procedures through a bounded exploratory illustration of six UK poultry listings, without claiming population-level estimation or full framework validation.

1.4 Contributions and scope

The paper makes four linked contributions. First, it defines two different benchmarks: C*, the closest functionally comparable conventional alternative, and A*k, the option that minimises the specified observed burden metric within the user's religiously acceptable and practically available set. Second, it distinguishes A*TB (lowest observed total accounting burden), A*N (lowest narrow monetary burden) and A*P (lowest displayed or adjusted price). Selection on one basis must not be reported as minimisation of another. Third, it sets out comparator rules—mandatory attributes, residual distance, ties, common support and stopping conditions—and requires separate assessments of source and inferential quality. Fourth, the exploratory UK poultry listings show how the observed *price* differential and feasible price comparator depend on unit basis, content, promotions and stock disclosures. These listings do not measure search, travel, delivery, verification or the total burden represented by the broader framework.

The principal output is therefore a measurement framework for future use, not an estimate of halal-related economic disadvantage in the United Kingdom. Provider costs and price formation are addressed as explanatory concepts rather than estimated mechanisms. Appendix C provides a separate preliminary Islamic evidentiary screen; it is optional, non-numerical and unvalidated, and cannot convert the retail-price illustration into a determination of Shariah validity or market fairness.

The empirical component comprises only six product listings, four frozen chicken-breast and two fresh whole-chicken products, from one retailer and one principal observation date. This narrow, non-probability illustration cannot establish a UK-wide mean price difference, the prevalence of any halal premium, the actual burden borne by Muslim households, or causal attribution to certification or market power. It is not a test of the protocol's reliability or external validity. Wider application within food markets requires new samples and household-level access data; transfer to Islamic finance, tourism or other sectors requires sector-specific definitions, units, time horizons and evidentiary rules.

II. CONCEPTUAL FOUNDATIONS

2.1 Halal as a credence attribute and assurance problem

Nelson (1970) distinguished between search and experience qualities, while Darby and Karni (1973) identified credence qualities that users may be unable to verify even after consumption. Halal status is generally a credence attribute, as consumers cannot reliably infer slaughter method, ingredient origin, cross-contamination controls, storage, handling or ongoing certification of a finished product. Thus, information asymmetry can lead to distrust, adverse selection, overpayment and market failure (Akerlof, 1970).

Certification, auditing, traceability, inspection, documentation, testing, supplier verification and Shariah review can all help to reduce uncertainty. These mechanisms may create economically needed costs and real value. However, the same institutional layer may also imply duplicated audits, fragmented standards, conflicts of interest or weak disclosure (Ab Talib et al., 2015; Annabi & Ibidapo-Obe, 2017; Soon et al., 2017). Measurement should recognise that assurance has costs, and not all assurance costs are efficient or justified.

2.2 Feasible sets, consideration sets and two kinds of religious acceptability

The choice depends on the available and considered alternatives (Sen, 1971; Train, 2009). Consideration-set models add that the evaluation of an option is costly per se and that consumers may screen alternatives before making a final choice (Roberts & Lattin, 1991). Religious identity may further reduce the scope for substitution and increase the search effort to locate sanctioned products, especially for minority markets (Coşgel & Minkler, 2004; Mumuni et al., 2018). Religious acceptability thus introduces a different screening rule: an option may be visible and economically comparable but not satisfy the user's declared doctrinal, certification or trust criterion.

The protocol distinguishes two sets. F_u(u,t,c;d) is the user-perceived religiously acceptable and practically available set for user u, time t, context c and declared rule d. It is appropriate for describing actual constrained choice. F_v(t,c;a) is the independently verified set under a stated evidentiary authority, a. It is the relevant set for objective claims about Shariah compliance, but it need not coincide with the user's perceived set. A retailer-disclosed halal claim may therefore be sufficient to enter an illustrative F_u while remaining insufficient to establish membership in F_v.

This is further separated from actual feasibility by practical availability. Options may be real or illusory based on stock, distance, delivery, timing, legal access, membership and liquidity. Likewise, the tradition of the poverty premium shows that a low nominal price does not guarantee a low effective burden when conditions of access and transaction are different (Caplovitz, 1963).

2.3 Transaction costs and the accounting-welfare boundary

Transaction-cost economics extends the measurement frontier beyond posted prices. Searching, comparing, travelling, negotiating, documenting, monitoring and switching are time- and resource-consuming activities (Coase, 1937; Stigler, 1961; Williamson, 1985). Observed time costs can be valued using a disclosed rule such as after-tax earnings or an appropriate shadow value for the context (Becker, 1965). The evidence of attribution is provider expenditure already embedded in the price, not an additional user charge.

The protocol is a measure of accounting, not an estimate of compensating variation. It does not estimate the loss of utility from the exclusion of a conventional alternative, which would require evidence of preferences or demand (Hicks, 1939). Thus, a term of lost utility is not included unless a separate welfare analysis is conducted. Search time should not be confused with financial discounting, liquidity and timing, which may still require explicit treatment at the sector level.

For assurance opacity, the analyst should record observable verification activities and information deficits, such as time spent, sources consulted, unresolved certification status, inconsistent descriptions and missing terms. An expected-loss component should be monetised only where probabilities and consequences can be credibly estimated and no equivalent risk allowance is already included in price, quality, service or assurance. Otherwise, uncertainty should be reported separately rather than assigned a speculative monetary value.

2.4 Quality, cost and market-price formation

Price differences are important only when considering tangible attributes, as suggested by characteristics and hedonic approaches (Lancaster, 1966; Rosen, 1974). Brand, origin, welfare, freshness, delivery, legal protection, liquidity and allocation of risk may influence value (Rao & Monroe, 1989; Dodds et al., 1991; Zeithaml, 1988). Therefore, the declared-content calculation is a

partial quality normalisation, not a full quality normalisation.

Economies of scale, entry barriers, concentration, differentiation and scarcity of providers can influence production costs and mark-ups (Bain, 1956; Porter, 1980; Tirole, 1988). Certification or governance costs can lead to an increase in overall costs. Competition, demand, bargaining, and promotions influence pass-through and mark-up. The price gap itself tells us nothing about the underlying mechanism, and an unexplained signed residual is a question of research, not an indication of exploitation.

2.5 Islamic moral economy and construct-development implications

Islamic economics assesses market behaviour in terms of justice, welfare, transparency, protection of wealth, moderation, accountability and removal of hardship (Chapra, 1992; Siddiqi, 2004; Sayer, 2000; Asutay, 2012, 2013). Contemporary accounts (Auda, 2008; Kamali, 2008) connect religious integrity to the protection of religion, life, intellect, family or lineage, wealth, public welfare and dignity. Terms such as tadlis or ghish, darar, mashaqqah and maslahah provide a normative vocabulary that transcends formal label compliance (El-Gamal, 2006; Kamali, 2013; Usmani, 2002). These principles are to be read carefully. But they do not turn a price calculation into a fatwa, a safety finding, or a legal judgement.

Construct development requires domain specification, boundary setting, item development and validation (Churchill, 1979; MacKenzie et al., 2011). Total burden is formative: price, fees, time, access expenditure and non-duplicative expected loss combine to form the measure rather than reflect a single latent trait (Diamantopoulos & Winklhofer, 2001). Perceptions such as trust, fairness and stress should be modelled separately. Accordingly, this article presents a structured assessment protocol, not a validated psychometric scale.

Table 1 synthesises the principal literature streams and their operational implications for the protocol.

Table 1. Literature streams and implications for protocol design

Literature stream	Core insight	Protocol implication
Halal behaviour and willingness to pay	Religiosity, trust, labels and quality perceptions influence payment and choice.	Do not equate realised payment with unconstrained willingness to pay.
Feasible choice and consideration sets	Choice depends on available, considered and religiously admissible alternatives; screening itself may be costly.	Report C^* and a separately constructed user-feasible comparator under an explicit acceptance rule.
Poverty-premium and access research	Nominally cheap options may carry a higher effective burden.	Measure stock, eligibility, travel, time and access conditions.
Credence and information economics	Halal claims are difficult for users to verify.	Record assurance evidence and verification burden; avoid uncalibrated monetisation.
Characteristics and hedonic comparison	Price reflects multiple ordinary attributes.	Specify mandatory matches, residual distance, common support and imbalance.
Industrial organisation	Cost, pass-through and mark-up depend on scale and market structure.	Keep provider cost and market mark-up analytically separate.
Islamic moral economy	Integrity, transparency and prevention of harm constrain appraisal.	Keep numerical measurement separate from any normative verdict.
Measurement theory	Formative burden and evidential judgement require different validation.	Keep accounting components, perceptions and normative assessment distinct.

Source: Author's synthesis.

III. METHODOLOGY

3.1 Conceptual and methodological research design

The study adopts a conceptual and methodological design comprising three connected elements: a structured integrative synthesis of 54 scholarly and authoritative sources, the development of a dual-comparator measurement framework, and a bounded exploratory illustration of selected retail-price procedures. The literature synthesis identifies relevant constructs and interpretive boundaries; framework development specifies comparator rules, outcome metrics and reporting safeguards. The six-product poultry illustration probes how those proposed rules operate under different displayed prices, content adjustments, promotions and availability statuses. It is not a systematic review or meta-analysis, a representative retail-price survey, a causal study, or a prospective validation of the proposed framework.

3.2 Literature-source selection and synthesis audit trail

The structured integrative synthesis drew on Google Scholar, Crossref and publisher records, backwards citation tracing, and authoritative institutional materials. Search families addressed halal premiums, willingness to pay, halal certification and logistics, credence attributes, feasible and consideration sets, religious consumption, poverty premiums, quality-adjusted prices and Maqasid-related affordability. A source was retained when it informed a construct definition, distinction, mechanism, comparison rule, safeguard or validation requirement and was cited in the article. The final conceptual corpus comprises 54 sources. Searches closed through judgement-based conceptual sufficiency rather than a reproducible systematic-review screening process; the synthesis was coded by one researcher. Table 2 records the audit trail and the limits of claims drawn from this source set.

The literature review was used to design the measurement protocol rather than estimate the frequency of any phenomenon. It neither establishes the absence of all comparable frameworks nor supports population-level claims about prices, availability or consumer hardship. Such claims would require separate empirical sampling and analysis.

The retailer-data reconstruction is described separately in Section 3.4 so that the conceptual source audit and the exploratory illustration are not conflated.

In interpreting the literature, the study distinguishes consumer-paid charges and time from provider-incurred costs, and observed monetary expenditure from unobserved welfare loss. User-perceived religious acceptability is kept separate from independently verified Shariah status. These distinctions determine which later numerical claims are permitted.

Table 2 summarises the recorded discovery channels, selection and coding rules, and limits of the integrative literature synthesis.

Table 2. Literature-synthesis audit trail and claim boundaries

Audit element	Recorded procedure	Claim boundary
Discovery channels	Google Scholar; Crossref, DOI and publisher records; backward citation tracing; official institutional sources.	Multiple routes were necessary because the construct spans economics, marketing, halal studies and measurement.

Query families	"halal premium"; "willingness to pay halal"; "halal certification cost"; "credence attribute"; "feasible choice set"; "consideration set"; "religious identity consumption"; "religiously sanctioned food search"; "poverty premium"; "quality-adjusted price"; "Maqasid affordability".	Queries identify conceptual families rather than an exhaustive systematic search universe.
Retention rule	A source had to alter a definition, boundary, mechanism, safeguard or validation requirement and be cited in the article.	Final conceptual corpus: 54 sources. Retailer listings (n=6) form a separate exploratory illustration.
Coding	Single-author coding by unit, comparator, burden bearer, mechanism, quality/value, market condition, affordability, integrity, uncertainty and data need.	Dependence on a single coder remains a limitation and a target for future validation.
Closure	Targeted searching ended when additional sources stopped adding a construct category or altering an operational boundary.	Judgement-based conceptual closure, not quantified saturation.
Contradictory evidence	Disagreement was retained rather than averaged.	Use disagreement to define scenarios, boundaries and validation tests.

Source: Author's audit trail. The synthesis is structured and integrative, not systematic or PRISMA-compliant.

3.3 Coding and construct derivation

Sources were coded by economic unit, comparator logic, burden bearer, proposed mechanism, product quality or value, market condition, welfare consequence, normative principle and data requirement. The synthesis was organised around three analytical layers: (i) user-side incidence and comparator construction, (ii) provider cost and retail price formation, and (iii) evidential quality and normative interpretation. The dual-comparator approach emerged from the distinction between the economically relevant conventional benchmark and the user's religiously screened feasible set. Metric-specific notation was developed because retailer listings normally disclose prices but not household search, travel, verification or other total-burden components. This is a conceptual derivation, not empirical construct validation.

3.4 Exploratory UK poultry illustration: data and limits

The worked illustration uses six Tesco UK online grocery listings recorded principally on 27 July 2026: four frozen chicken-breast listings (one conventional and three halal-labelled) and two fresh whole-chicken listings (one conventional and one halal-labelled). The frozen products support an exploratory price-basis and availability exercise; the whole-chicken pair provides a separate descriptive contrast with unresolved quality differences. The common retailer and principal observation date hold certain channel conditions constant, but the listings are a small, non-probability set rather than a representative sample of UK poultry, retailers or Muslim consumers. The original selection was not prospectively preregistered; comparison and stopping rules were applied retrospectively and are presented as illustrations, not confirmatory tests.

Recorded attributes include standard and Clubcard prices where displayed, pack weight, displayed unit price, declared chicken content where available, fresh or frozen format, retailer halal or assurance claims, and recorded stock status. The exact observation time, signed-in status, delivery postcode, complete contemporaneous page archives and promotion end dates were not retained. Consequently, historical and postcode-specific stock or eligibility cannot be independently reconstructed for a hypothetical household.

Product-description pages were consulted again on 29 July 2026 for selected origin and assurance details: the Shazans and Tesco whole-chicken descriptions both stated British origin and Red Tractor certification, while the Tesco listing presented additional higher-welfare claims. All six product URLs were rechecked on 1 August 2026 where available. Jahan and Shazans were displayed as out of stock at that later recheck; later status was not imposed retrospectively on 27 July. The whole-chicken pair is therefore used for descriptive price comparison, not as evidence of a feasible purchase set on that earlier date. A separate editorial link check on 22 October 2026 confirmed that all six cited Tesco product URLs remained accessible and supported selected product-identification and descriptive claims; the current pages were not used to authenticate or replace July prices, promotions or availability.

For the limited feasible-set demonstration, a retailer-disclosed halal claim operates as a deliberately weak proxy for user-perceived religious acceptability; it is not independent verification of Shariah compliance. Practical availability is represented only by recorded displayed stock for the relevant scenario. Because delivery, travel, search, verification, trust and consumer-specific access are unobserved, the exercise can identify only A*P on a defined price basis, not A*N or A*TB. Results are illustrative listings rather than household burden estimates.

3.5 Retrospective comparison rules for the illustration

Table 3 identifies the comparison rules applied retrospectively to the selected listings: a same-format frozen-breast comparator, a descriptive fresh whole-chicken pair, a disclosed acceptance-and-stock proxy, and rules for residual imbalance and non-comparability. The unit and eligibility scenarios must be held constant within each price differential. Applying these rules to this small dataset shows their practical meaning but cannot establish that they will perform reliably across assessors, retailers, times or localities.

Table 3. Comparator-construction rules applied to the Tesco illustration

Comparison	Specified comparison rule	Selected comparator or candidate	Comparability status
Frozen breast	The main outcome is the displayed price per kilogram, with price per kilogram of declared chicken content used as a sensitivity measure. Products must be listed by the same retailer, on the same platform and date, and must be frozen, skinless and boneless chicken breast in broadly comparable pack sizes. Price is not used to select the closest match.	Tesco Chicken Breast Fillet 1 kg. Residual imbalance: declared content, origin, brand, nutrition, assurance, water retention and cooking yield.	Partially matched/adjusted. The declared-content result is a sensitivity calculation, not a full quality normalisation.
Whole chicken	Outcome unit: displayed £/kg. Mandatory: same retailer/platform/date, fresh whole chicken, overlapping weight range. British origin and Red Tractor are assessed from the 29 July recapture.	Tesco Large Whole Chicken. Residual imbalance: detailed higher-welfare disclosure and other unobserved qualities.	Descriptive with unresolved imbalance; no clean halal attribution.
Feasible comparator	Under the stated proxy, a listing enters the user-perceived acceptable set when the retailer labels it halal; the analyst also requires recorded 'in-stock' status. Standard and Clubcard scenarios are evaluated separately, with eligibility disclosed. This is a retrospective illustration, not validation of real household access.	A^*_P is the available halal product with the lowest displayed £/kg product price. Jahan is excluded when displayed out of stock.	Price proxy only; no claim that it minimises total burden.

Tie/common support	Where functional candidates tie, retain them or report a range. If mandatory attributes fail or residual quality imbalance breaches the declared threshold, stop and report 'no valid C*' rather than force a clean match.	No tie occurred in the observed candidate sets.	The stopping rule prevents disclosure alone from turning an unmatched pair into a matched comparison.

Source: Author's protocol. These rules were applied retrospectively to the recorded dataset; future confirmatory applications should prespecify or preregister them before observing outcomes.

IV. THE DUAL-COMPARATOR MEASUREMENT FRAMEWORK

4.1 Neutral outcome metric and analytical layers

The *proposed* construct is the halal-related burden differential (HBD), a neutral signed difference between a focal halal or Shariah-compliant option, H, and a declared comparator under a specified burden metric. A positive value denotes a positive measured differential, zero denotes equality on that metric, and a negative value denotes a discount. The labels do not, on their own, establish a causal halal effect, an economic welfare loss, exploitation, religious validity or a policy justification. In the exploratory poultry exercise, only selected price metrics are observed; the larger total-burden construct is not estimated.

Let k identify the fully specified observed metric, including both the burden scope and the unit's basis. The core scopes are total accounting burden, B_{TB}; narrow monetary burden, B_N; and displayed or adjusted price, B_P. When price is expressed on more than one basis, for example, product weight and declared-content weight, each basis must be stated explicitly, and the comparator selection must be repeated for each. C^* is the closest functionally comparable conventional option under a declared matching protocol. F_u(u,t,c;d) is the user-perceived religiously acceptable and practically available set. The metric-specific feasible comparator is:

$$Ak^*=arg\,min_{o\in Fuu,t,c;dBko}, \qquad k\in K. \quad (1)$$

This notation is essential to the scope of the evidence. A product chosen because it minimises displayed price must be labelled A*P, not A*TB. Likewise, a per-kilogram product-price comparison and a per-kilogram declared-content comparison are different metric specifications, each requiring internally consistent comparator selection. Where the information necessary for total burden or even narrow monetary burden is missing, the analyst should report the narrower observed outcome and explicitly label the unmeasured components.

$$HBDk=BkH-BkC^*=BkH-BkAk^*+BkAk^*-BkC^*. \quad (2)$$

Under a single fully specified metric k, the first bracket in Equation (2) is the focal-choice differential (FCDk): the gap between the focal option and the least burdensome observed feasible option under that metric. The second is the religiously screened feasible-set differential (RFDk): the gap between the feasible minimum and the conventional comparator. The identity is arithmetic; neither component isolates a causal effect of religion. In particular, the price-based RFD illustrated in Section V must not be described as the RFD of total accounting burden.

4.2 Comparator construction

"Closest" must be operationalised rather than asserted. Price should normally be excluded from the

matching rule when it is the outcome. First, the analyst specifies the mandatory attributes without which comparison is invalid, then applies a disclosed distance or ranking rule to the remaining attributes, resolves ties and enforces common support. A valid protocol must allow for the conclusion that there is "no comparable conventional option".

Table 4 converts this logic into a seven-step selection sequence and links each decision to the strongest reporting label supported by the available evidence.

Table 4. Comparator-selection protocol and permitted reporting labels

Step	Required decision	Permitted output
1. Define the outcome	Specify k, burden scope, unit basis, quantity, horizon and decision context.	B_{TB}, B_N or B_P on a declared unit basis; no switching of metric or basis within a decomposition.
2. Define mandatory attributes	List the function and attributes without which comparison is invalid.	Candidate pool or "no comparable candidates."
3. Rank residual distance	Apply a prespecified matching, stratification, regression or mixed-attribute distance rule; exclude the outcome from matching.	Provisional C^* with balance diagnostics.
4. Apply tie and common-support rules	Retain tied comparators or apply a transparent tie rule; stop when imbalance exceeds the limit.	Fully matched; partially matched/adjusted; descriptive with imbalance; or not comparable.
5. Define the user rule d	State the user's belief, jurisprudential school, certifier, expert or documentary criterion.	User-perceived religiously screened candidate set F_u.
6. Apply practical availability	Record stock, place, timing, delivery, legal access, liquidity and eligibility.	Context-specific F_u or an empty set.
7. Select metric-specific comparator	Minimise the declared observed metric only.	A^*_{TB}, A^*_N or A^*_P; never an unlabeled A^*.

Source: Author's construction.

4.3 User-side burden and the accounting-welfare boundary

$$BTBo = Mo + Feeo + TCo + ACo + ERo. \quad (3)$$

M denotes the purchase price or contractual payment; Fee denotes mandatory provider charges not included in M; TC denotes monetised search, travel, verification and documentation time; AC denotes third-party payments or out-of-pocket access expenditure, such as fares; and ER denotes incremental expected residual loss. Provider delivery charges are classified as 'Fee', whereas independently incurred travel or other access expenditure is classified as 'AC'. Each component is recorded only once.

ER is included only when its probability and consequence can be credibly estimated and the same risk is not already represented in price, quality, service or assurance. Narrow monetary burden is $B_N(o)$ = M(o) + Fee(o). The displayed or adjusted price, $B_P(o)$, must state whether it is a pack price, a product-unit price or an adjusted unit price. Each distinct unit basis is treated as a separate metric specification. The framework does not estimate compensating variation or forgone utility.

$$BTBo;q,T = q \times VBo + FBo;T. \quad (4)$$

VB is the per-unit variable burden, and FB is the fixed or semi-fixed burden allocated over quantity q and horizon T. Initial search, account registration, certificate verification or a journey serving several

products should not be allocated in full to every unit. Allocation assumptions must be disclosed and subjected to sensitivity analysis.

4.4 Quality adjustment and comparability classes

The comparison must account for ordinary differences in product quality before suggesting that a gap has a halal-related explanation. In food markets, candidate variables include pack size, declared content, cut, fresh or frozen status, cooking yield, water retention, nutrition, welfare, origin and delivery conditions. Comparisons are classified as fully matched, partially matched or adjusted, descriptive with unresolved imbalance, or not comparable. Adjustment by declared chicken content is only one limited sensitivity analysis and does not exhaust quality differences or reveal causal certification costs.

A difference should be explained in terms of either halal-specific assurance or broader tayyib value only if a difference remains after accounting for ordinary product attributes and there is distinct proof of it. An attribute already used in matching or modification shall not be counted again as an additional value component linked to halal. When data does not clearly separate halal-related assurance from regular quality, the difference should be classified as an unexplained aspect of the observed price or burden disparity.

4.5 Provider cost and market-price formation

User-side incidence and provider attribution are distinct questions. Where provider records are available, incremental provider costs may be organised as follows:

$$\Delta PC=\Delta ASSUR+\Delta PROC+\Delta LOG+\Delta RISK+\Delta FIXED+\varepsilon C. \quad (5)$$

ΔASSUR captures incremental certification and Shariah governance expenditure; ΔPROC captures segregation, traceability and integrity-process costs; ΔLOG captures distribution and access costs; ΔRISK captures incremental legal, ownership, liquidity, operational or capital costs; ΔFIXED captures scale-sensitive fixed-cost allocation; and ε_C denotes a signed provider-cost residual.

Market price should not be represented as the sum of “demand value” and “margin” as though they were independent costs. A safer accounting representation is:

$$Po=MCo+\mu o, \qquad \Delta P=\Delta MC+\Delta\mu. \quad (6)$$

MC is the marginal or unit cost under a disclosed allocation rule, and μ is the monetary mark-up. Incremental assurance costs may contribute to ΔMC. Demand, competition, differentiation, scarcity, bargaining and promotions influence pass-through and Δμ; they are explanatory determinants rather than additional provider-cost terms. Causal pass-through requires a separate empirical identification strategy. A positive residual and a high markup alone do not establish exploitation; further evidence is required.

4.6 Consequences, uncertainty and data quality

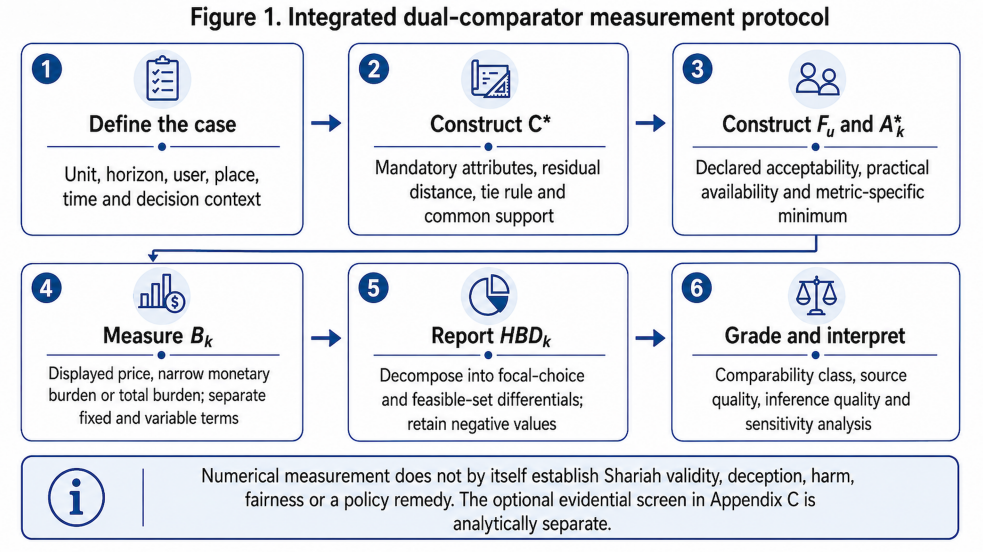
Affordability is a possible consequence of burden, not another term to be added to the burden itself. A future household application should report absolute exposure, positive-only exposure if relevant, the disclosed resource denominator and differences across household groups. No universal affordability threshold is assumed. Where a resource denominator is non-positive, report the absolute exposure and

the denominator rather than calculate an unstable ratio. No household income, consumption basket or affordability indicator is measured in the present six-listing illustration.

Data and inference quality are reported separately. Source quality concerns directness, timestamps, location, eligibility, archiving and independent verifiability; inferential quality concerns matching, proxy dependence, assumptions and external validity. The A–D grades in this paper are descriptive reporting aids, not calibrated or validated scales, and must be assigned to particular outputs with reasons. A indicates directly reproducible evidence or strong identification on the respective dimension; B indicates direct but incomplete evidence or a close descriptive inference; C indicates proxies, partial adjustment or model-dependent inference; and D denotes exploratory or hypothetical construction. Use 'not assessable' where necessary evidence is absent; do not average grades into a composite score.

Figure 1 summarises the protocol as a six-stage sequence, moving from case definition and comparator construction to metric-specific measurement, grading and bounded interpretation. It also emphasises that numerical measurement does not, by itself, establish Shariah validity, deception, harm, fairness or an appropriate policy response. The optional evidential screen in Appendix C remains analytically separate.

Figure 1. Proposed dual-comparator measurement protocol (not empirically validated)



Source: Author’s construction.

4.7 Boundary between measurement and normative assessment

A numerically precise HBD can remain normatively indeterminate, and even strong assurance may coexist with limited affordability for particular households. Numerical measurement does not itself determine Shariah validity, deception, severe harm, fairness or the appropriate policy response. Appendix C therefore proposes an optional preliminary evidentiary screen that separates user-perceived acceptability from independently verified integrity. That screen has not been validated by Shariah experts and was not administered as a substantive compliance audit of the poultry listings.

4.8 Empirical demonstration and validation status

The formal protocol specifies what could be measured if consumer-specific prices, fees, access expenditures, time costs, availability, eligibility and credible risk inputs were collected. The Tesco snapshot cannot populate those fields. Its purpose is confined to illustrating two candidate product formats, alternative unit-price bases, a weak retailer-disclosure acceptance proxy and available-price rankings under recorded stock and Clubcard scenarios. The observed price comparator A*P must not be relabelled as A*N or A*TB, and a conditional listing difference must not be described as a representative, causal or validated estimate of halal-related consumer burden.

Full evaluation of the framework remains a future task: assessors should prospectively specify and apply matching and stopping rules; multi-retailer panels should test price comparisons across space and time; and household studies should collect travel, search, delivery, verification, opportunity-cost and access information. Inter-rater reliability, validity, sensitivity to religious acceptance criteria and normative appraisal require distinct assessments. This validation agenda is elaborated in Appendix B.

V. EXPLORATORY ILLUSTRATION: UK POULTRY RETAIL PRICES

5.1 Product records and candidate sets

Table 5 records the six selected listings and their analytical roles. Four frozen chicken-breast products are considered for the price-based comparison; the two fresh whole-chicken listings are assessed only as a descriptive contrast. Neither subset is a probability sample, and no household-level burden has been observed.

Table 5. Six exploratory Tesco poultry listings recorded on 27 July 2026, with later descriptive checks

Product	**Status/format**	Recorded listing price	**Attributes and analytical role**
Tesco Chicken Breast Fillet 1 kg	Conventional; frozen; skinless/boneless	£7.00/kg	90% chicken; displayed as available; C^* for the frozen-breast comparison.
Halal Eat Chicken Breast Fillets 1 kg	Halal; frozen; skinless/boneless	£7.00/kg; £5.60/kg Clubcard	80% chicken; displayed as available; lowest available halal product-price option under standard prices.
Humza Chicken 1 kg	Halal; frozen; skinless/boneless	£7.50/kg; £4.90/kg Clubcard	80% chicken; displayed as available; lowest available halal product-price option for eligible Clubcard users.
Jahan Frozen Chicken Breast Fillet 1 kg	Halal; frozen; skinless/boneless	£5.70/kg; £4.55/kg Clubcard	80% chicken; displayed as out of stock on 27 July; excluded from the available-price scenario.
Tesco Large Whole Chicken 1.7–2.1 kg	Conventional; fresh; whole	£3.09/kg; £2.71/kg Clubcard	British; Red Tractor; detailed higher-welfare claims; C^* candidate for whole chicken.
Shazans Halal Whole Chicken Large 1.8–2.2 kg	Halal; fresh; whole	£3.92/kg	HFA approval; British chicken and Red Tractor stated at recapture; no equivalent detailed higher-welfare claim observed. Displayed as out of stock at the 1 August recheck; postcode-specific availability on 27 July was not preserved; not used to construct A^*_p.

Source: Author-recorded observations and Tesco Stores Limited (2026a–2026f). Prices and recorded stock refer to 27 July 2026; selected origin and assurance descriptions were checked on 29 July, and all six product URLs were reverified on 1 August. No timestamped, signed-in or postcode-specific

archive was retained.

Frozen-breast products share the retailer, principal observation date, broad cut and frozen skinless/boneless format, but declared content, brand, origin, water retention, cooking yield, nutrition and assurance remain incompletely balanced. Expressing price per kilogram of declared chicken content tests sensitivity to one observable attribute and does not produce complete quality adjustment. The whole-chicken pair overlaps in format, weight, stated British origin and Red Tractor assurances at the 29 July description check, but detailed welfare disclosures are unequal. Shazans' 27 July postcode-specific availability was not preserved and its 1 August page was out of stock. The pair therefore cannot establish a reliable feasible-set differential or a causal halal price effect.

5.2 Frozen chicken breast: displayed prices and compositional sensitivity

Halal Eat and Tesco Chicken Breast Fillet were each recorded at £7.00 per kilogram at standard prices, giving a zero displayed product-weight price differential. The listings reported 80% and 90% chicken content, respectively. Dividing the prices by the declared shares gives approximately £8.75 and £7.78 per kilogram of *declared chicken content*, or a £0.97 (12.5%) difference relative to the Tesco comparator. This calculation is sensitive to declared composition alone. It does not measure actual edible yield or establish a fully quality-adjusted halal premium.

Humza declared 80% chicken content and was listed at £7.50 per kilogram, a displayed price difference of £0.50 (7.1%) relative to Tesco; per kilogram of declared chicken content, the observed difference was approximately £1.60 (20.5%). For the recorded Clubcard scenarios, Halal Eat and Humza had negative product-weight differentials of 20.0% and 30.0%, respectively, and declared-content differentials of approximately -10.0% and -21.3%. These are conditional, date-specific listing comparisons, not estimates of persistent price relationships; the analysis does not observe the prevalence or duration of promotions or verify any particular shopper's eligibility.

Table 6. Exploratory frozen chicken-breast price differences and declared-content sensitivity

Halal option and price basis	Product-price HBD from Tesco £7.00/kg	Price per kg of declared chicken content	Declared-content-basis difference
Halal Eat, standard	£0.00 (0.0%)	£8.75 vs £7.78	£0.97 (12.5%)
Halal Eat, Clubcard	-£1.40 (-20.0%)	£7.00 vs £7.78	-£0.78 (-10.0%)
Humza, standard	£0.50 (7.1%)	£9.38 vs £7.78	£1.60 (20.5%)
Humza, Clubcard	-£2.10 (-30.0%)	£6.13 vs £7.78	-£1.65 (-21.3%)

Source: Author’s calculations from Tesco Stores Limited (2026a, 2026b, 2026e). Percentages use the Tesco comparator as the common denominator. Negative values indicate discounts.

5.3 Price-proxy decomposition, availability and eligibility

Under the retailer-disclosure proxy and recorded standard-price availability scenario, Halal Eat has the lowest displayed price among the observed available halal frozen-breast listings on both product-weight and declared-content price bases. If Halal Eat is the focal product, the observed focal-choice difference is zero; relative to Tesco, the price-based feasible-set difference is zero per kilogram of product and £0.97 (12.5%) per kilogram of declared chicken content. For a focal Humza purchase at standard prices, the declared-content difference of about £1.60 can be decomposed into approximately £0.63 of focal-choice difference and £0.97 of feasible-set difference per kilogram of declared chicken

content. This is a descriptive decomposition of observed listed prices, not an estimate of total user burden or the causal impact of a religious constraint.

In the Clubcard-price scenario, Humza has the lowest observed available halal listing price under both reported bases. A focal selection of Halal Eat may then carry a positive within-feasible-set price differential even though its displayed price remains lower than that of the conventional Tesco comparator. Jahan's lower listing price does not qualify it as the observed available price comparator because the 27 July record reported it out of stock. The price-proxy set remains uncertain in the absence of saved delivery-postcode and customer-status details. Accordingly, no claim is made that any listed product minimises actual consumer travel, verification, delivery, monetary or total burden.

5.4 Fresh whole chicken: a descriptive comparison with residual imbalance

Shazans whole chicken was listed at £3.92 per kilogram, versus £3.09 for Tesco Large Whole Chicken: a raw listing gap of £0.83 (26.9%). Relative to Tesco's recorded temporary Clubcard price of £2.71, the gap was £1.21 (44.6%). Subsequent product descriptions indicated British origin and Red Tractor claims for both, while Tesco supplied additional detailed higher-welfare disclosures that were not equivalently observed for Shazans. Because ordinary characteristics and assurance disclosures are not fully balanced, and the 27 July postcode-specific availability of Shazans is unknown, these figures are *descriptive listing differences only*. They cannot support a feasible-set estimate or an attribution of the gap to halal status.

5.5 Source and inferential quality

Table 7 records source and inferential quality separately for each output; these author-assigned, ordinal grades communicate evidential limitations; they are not validated scales or indicators of statistical representativeness.

Table 7. Source and inferential quality of the exploratory price outputs

Output	Result	Source grade	Inference grade and reason
Frozen-breast standard price	Halal Eat 0.0%; Humza 7.1%	B	B: direct snapshot prices and close functional match, but context and archival detail are incomplete.
Declared-content sensitivity	Halal Eat 12.5%; Humza 20.5%	B	C: declared content is direct, but it is an incomplete quality proxy.
Clubcard comparisons	Declared-content discounts of 10.0% and 21.3%	B	C: eligibility and promotion persistence are conditional and incompletely archived.
Price-proxy ranking	Halal Eat at standard price; Humza with Clubcard	B	C: price and displayed stock are observed, but user location, trust and total burden are not.
Whole-chicken raw difference	26.9%; 44.6% against Clubcard	B	C: direct prices with unresolved welfare and quality imbalance.
Provider attribution and affordability	Not estimated	Not assessable	Not assessable: provider costs, household resources, consumption and access data are absent.

Source: Author’s grading under Section 4.6. Grades apply to outputs, not to the retailer, supplier or certifier.

5.6 What the exploratory illustration does—and does not—show

The six listings demonstrate limited operational points. First, a nominally identical product-weight price may produce a different value when the unit basis changes to declared chicken content. Second, customer-specific promotional eligibility can reverse the sign and ranking of observed prices. Third, an out-of-stock listing cannot be treated as an available comparator under the stated stock proxy. Fourth, unmatched welfare or other quality attributes prohibit attribution of a price gap to halal status. These are case-specific demonstrations of comparison rules, not estimates of their frequency or economic magnitude in the UK market.

The illustration cannot measure search time, transport, delivery, certification verification, consumer trust, uncertainty, monetary access expenditure, household welfare or provider cost; no consumer participated in the study. It also does not validate the dual-comparator framework, establish a representative halal price premium or test the proposition that scarce local access increases total burden. The data are sufficient to motivate further data collection and demonstrate specified calculations, but not to generalise to Muslim-minority markets or establish a causal explanation for any observed gap.

VI. DISCUSSION

6.1 Methodological contribution beyond a single comparator

A single conventional-price comparator reports only the gap between a focal option and its closest functionally comparable conventional alternative (C*). Even where a descriptive gap can be calculated, that comparison does not distinguish the focal consumer's choice from the minimum measured burden within the user's acceptable and practically available set. The proposed dual-comparator framework makes that intermediate comparison explicit. Its contribution is not a new economic identity but a replicable decision procedure for defining, matching and evaluating relevant options.

For each fully specified metric k, the focal-choice differential (FCDk) compares the focal option with the feasible minimum A*k, while the religiously screened feasible-set differential (RFDk) compares A*k with C*. This decomposition may help distinguish a relatively costly focal choice from a differential that remains even at the observed feasible minimum. Nevertheless, RFDk is conditional on the declared user rule, observed availability, metric and unresolved attributes. It cannot be interpreted as a causal estimate of the 'cost of religion'.

The metric distinction is equally substantive. The option minimising displayed price (A*P) need not minimise narrow monetary burden (A*N), and neither need minimise total accounting burden (A*TB) once travel, search and verification are observed. In this study only limited A*P scenarios can be illustrated. Future implementation must report those comparator labels and the price unit explicitly, rather than using a retail-price exercise to make claims about household welfare.

6.2 Theoretical conditions for convergence and divergence

Within a specified metric k, FCDk is zero when the focal choice itself minimises observed burden among eligible options. RFDk is zero when that feasible minimum and the conventional comparator C* have the same value on the specified metric, even if the products are not identical. The two

comparators may coincide only if the conventional benchmark also satisfies the user's declared religious acceptance and practical availability rules. These are properties of the measurement construction, not findings about the population distribution of consumer burden.

In principle, the feasible-set and conventional benchmarks may diverge because of geography, eligibility, limited supply, brand, assurance, promotions or unresolved quality characteristics. For example, travel to a distant specialist retailer could increase accounting burden even if its shelf price were low, while a conveniently delivered higher-price product might impose lower total burden. These are conceptual possibilities that require household and location evidence; the present Tesco listings do not test them.

Comparable future estimates require consistent units, explicitly documented user-acceptance rules, repeated stock and price observations, and adequate balance of ordinary attributes. Where credible alternative screening rules exist, scenario analysis should disclose how each changes the feasible set and reported measure. Without common-support safeguards, neither price nor total-burden comparisons should be given a clean halal-attribution label.

6.3 Implications for empirical research

A confirmatory application should prespecify the unit of analysis, burden metric, mandatory matching attributes, residual-distance and common-support rules, tie and stopping rules, consumer acceptance criteria, and practical-availability tests. Selection on the outcome (for example, price) should not determine the closest functional match. Independent assessors should record balance diagnostics and permit a finding that no credible C* exists. Prospective audits should test whether the proposed protocol produces reproducible decisions across analysts and contexts.

Price and stock panels should cover several retailers, localities, product categories and dates, retaining timestamped product pages, postcodes, promotional eligibility and stock evidence. To advance beyond price comparisons, user-level studies should additionally observe search effort, travel expense, delivery fees, verification time, failed purchase attempts and shared fixed costs. Such measurements would permit tests of A*N and A*TB and of how user profiles affect the estimated differential.

Provider-cost attribution, pass-through and retail mark-up require independent supplier or retailer accounting evidence and a suitable identification strategy. Likewise, household affordability and distributional effects require income, consumption and access data, not just listed prices. Each result should report separate source and inferential grades, quality balance and sensitivity to alternate assumptions. The present exploratory observations should be treated as a design exercise that informs these more demanding tests.

A particularly informative next step would compare places with different levels of halal retail access while following the same product formats through time. Such studies could examine whether price-based feasible rankings differ from total-burden rankings after travel, search, verification and delivery are included; could test the reliability of comparator selection; and could assess whether the proposed framework remains useful beyond UK poultry. Until these analyses are conducted, the broader consumer-burden and cross-sector claims are theoretical propositions, not empirical findings of this article.

6.4 Implications for providers, certifiers and policy

For retailers and certifiers, the framework suggests the potential value of recording product composition, certification scope, promotion conditions, stock status by postcode and stable documentary links. Such disclosure *may* reduce verification effort and increase the auditability of future measurements, but the six listings do not measure any resulting time savings or consumer outcomes. Providers can also distinguish price, mandatory fees and externally incurred access costs in their reporting. These are proposals for better information, not empirically tested effects.

The protocol is not itself evidence for regulatory intervention. A positive price or burden differential does not automatically justify subsidy, sanctions, regulation or a finding of exploitation. Any proposed remedy would require separate evidence about the underlying mechanism, distributional consequences, competing product attributes, assurance value, legal authority, proportionality and possible unintended effects. The exploratory poultry comparison does not establish those conditions.

6.5 Limitations

The empirical illustration is restricted to six selected products, two product formats, one online retailer and one principal observation date. It is a non-probability, retrospective comparison, not a representative sample, a longitudinal market audit or a household study. Original records lack the precise observation time, postcode, signed-in status, complete contemporaneous webpage archives and promotion end dates. Later page checks do not reconstruct earlier offers or availability, and displayed stock cannot establish whether a specific consumer could actually purchase an item.

Declared chicken content is a partial compositional sensitivity basis only: it does not control cooking yield, water retention, taste, nutrition, welfare, origin, brand, production processes or assurance. The fresh whole-chicken pair has unresolved welfare-disclosure and availability differences. Selection and comparator rules were not prospectively preregistered, so the illustration cannot serve as an independent confirmation of those rules. Calculated percentages reflect conditional observations and do not indicate prevalence, stable pricing or causal halal-related effects.

The structured integrative review is selective rather than exhaustive, was coded by one author and did not use systematic-review or PRISMA procedures. The framework itself has not undergone prospective inter-rater reliability testing, construct validation, external validation, or comparison with independently measured household burden. The A–D reporting grades are unvalidated qualitative aids. Appendix C's optional Islamic evidentiary screen likewise awaits expert content validation. Adaptation outside retail food would require sector-specific redevelopment rather than direct transfer.

The most important substantive limitation is that the study's motivating proposition—religiously screened access may impose search, travel and verification burdens even where shelf-price gaps are small, zero or negative—is not tested by the retailer listings. The manuscript develops a way to investigate that proposition, but estimating such burdens requires repeated market observation combined with household-level evidence. The distinction between proposing a measurement procedure, illustrating selected calculations and empirically validating the full construct must therefore be maintained.

VII. CONCLUSION

This study contributes a dual-comparator measurement framework for halal-related consumer burden rather than a representative estimate of that burden. It separates the closest functionally comparable conventional benchmark (C*) from the feasible minimum (A*k) under a declared religious-acceptance rule, availability constraints and a fully specified metric. In particular, the lowest price option (A*P), lowest narrow monetary-burden option (A*N) and lowest total accounting-burden option (A*TB) must not be treated as interchangeable. A metric-consistent decomposition then distinguishes a focal-choice differential from a religiously screened feasible-set differential, without asserting that either component identifies a causal halal effect.

The framework separates consumer incidence from provider cost and market mark-up, accounting burden from unmeasured utility loss, and user-perceived acceptability from independently evidenced Shariah compliance. Its exploratory UK poultry illustration demonstrates selected price and comparator rules: identical displayed prices produced a positive declared-content-based difference; promotional eligibility reversed some listed price differentials; and out-of-stock listings were excluded from the stipulated available-price scenario. Ordinary product-quality and availability imbalances prevented causal attribution. No household search, travel, verification or full accounting burden was measured.

The principal contribution is thus a transparent protocol and a deliberately limited illustration, not proof of a market-wide halal premium or validation of the proposed instrument. Future research should conduct prospective, multi-retailer and longitudinal audits, archive postcode-specific availability and eligibility, observe household access costs and consumption conditions, and test comparator reliability with independent assessors. Provider-cost explanations, Shariah integrity and normative questions about fairness or policy should remain separate enquiries requiring their own evidence. Credible construction of the unit, comparable alternatives and user-feasible set must precede numerical precision and interpretation.

DECLARATIONS

Data and Materials Availability

The exploratory illustration uses six author-recorded retailer listings and product-page URLs referenced below (Tesco Stores Limited, 2026a–2026f). It is based on a principal observation on 27 July 2026, descriptive product-page checks on 29 July and URL rechecks on 1 August. The author did not retain full timestamped, signed-in or postcode-specific webpage archives. Consequently, these observations are a bounded reconstruction rather than a fully reproducible historical market panel. No household data or proprietary provider-cost data were used, and the six listings are not presented as a representative dataset.

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Conflict of Interest

The author declares that there are no financial, professional, personal or other competing interests that could have influenced the research or its presentation.

Ethics Approval

This study is conceptual and is based on published literature, publicly accessible retailer information and secondary-source materials. It did not involve human participants, the collection or processing of personal data, or primary fieldwork. Accordingly, formal ethics approval and informed consent were not required.

Author's Contribution

The author was solely responsible for the conceptualisation, methodology, literature synthesis, data collection, analysis, interpretation, preparation of the original manuscript, and review and editing of the final article.

Generative Artificial Intelligence Use

Generative artificial intelligence tools were used for language refinement, structural review, consistency checking and editorial assistance. The author critically reviewed, verified, and revised all AI-assisted outputs. The author takes full responsibility for the intellectual content, conceptual framework, methodology, source selection, citations, analysis, interpretation and final form of the manuscript. Generative AI was not used as an empirical data source or treated as an author.

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APPENDIX A. MEASUREMENT AND REPORTING RULES

A1. Core notation and measures

BPo=displayed price on the declared unit and eligibility basis. (A1)

BNo=Mo+Feeo. (A2)

BTBo=Mo+Feeo+TCo+ACo+ERo. (A3)

Ak=arg mino∈Fuu,t,c;dBko, k∈K.* (A4)

HBDk=BkH-BkC=FCDk+RFDk.* (A5)

FCDk=BkH-BkAk.* (A6)

RFDk=BkAk-BkC*.* (A7)

Relative HBDk=100×HBDkBkC, BkC*>0.* (A8)

Absolute and relative results should be reported together, and negative values should be retained. When percentage components are expected to sum, use the same denominator $B_k(C^*)$. Every decomposition must use the same fully specified metric k, including the unit basis, user rule, availability and eligibility conditions.

A2. Fixed burden and optional household aggregation

BTBo;q,T=q×VBo+FBo;T. (A9)

$Ej=iqji\times\Delta VBji+\Delta FBji.$ (A10)

$E_j^+ = \sum_i \max(q_{ji} \times \Delta VB_{ji} + \Delta FB_{ji}, 0).$ (A11)

Each item-level ΔFB term represents the share of incremental fixed burden allocated to that item, and the shares sum to the household's total incremental fixed burden. Net exposure and positive-only exposure answer different questions and should be reported separately. Any income or resource ratio requires a stated denominator, consistent time periods, a household-equivalence assumption and sensitivity analysis.

A3. Provider and market attribution

$\Delta PC=\Delta ASSUR+\Delta PROC+\Delta LOG+\Delta RISK+\Delta FIXED+\varepsilon C.$ (A12)

$Po=MCo+\mu o; \qquad \Delta P=\Delta MC+\Delta\mu.$ (A13)

Cost allocation, pass-through and causal identification must be disclosed separately. Demand, competition, scarcity, bargaining and promotion determine pass-through and mark-up; they are not additional cost terms. Neither a positive residual nor a high mark-up establishes exploitation without further evidence.

A4. Minimum empirical reporting set

• Focal option H; C^* protocol; declared user rule d; F_u(u,t,c;d); and A^*_{TB}, A^*_N or A^*_P.

• Metric k; unit; quantity; user/context; location or postcode; date and time; signed-in status; availability; eligibility; and horizon.

• Mandatory matching variables; residual-distance rule; tie rule; common support; comparability class; and remaining imbalance.

• Price; provider fees; time valuation; access expenditure; expected-loss rule; and fixed/variable allocation.

• Standard and promotional prices separately, with membership conditions and promotion periods.

• Provider cost, unit-cost allocation, pass-through design and mark-up evidence where available.

• Absolute and relative HBD; FCD; RFD; household exposure and distributional results where relevant.

• Source-quality and inference-quality grades; archived evidence; sensitivity analysis; and limitations.

• Any normative or Shariah assessment reported separately from the numerical measure, with the authority and evidence scope stated.

APPENDIX B. EMPIRICAL VALIDATION AGENDA

Table B1 translates unresolved claims into research designs capable of testing comparator sensitivity, proxy error, promotional instability, attribution, transparency burden and assessor reliability.

Table B1. Testable propositions and validation designs

Proposition	Expected observation	Suggested design

P1: Comparator sensitivity	Magnitude, sign or comparability class changes as ordinary-attribute balance improves.	Multi-stage matching audit with balance diagnostics and repeated prices.
P2: Proxy error	A^*_P and A^*_N mis-rank options relative to A^*_{TB} when access and transaction burden differ.	User-profiled store, travel, delivery and verification mapping.
P3: Feasible-set differential	RFD_k varies with acceptability rule, scarcity, geography and eligibility.	Scenario analysis with alternative documentary, certifier and doctrinal rules.
P4: Promotion instability	Single-date estimates overstate structural differences when promotion frequency differs.	Weekly panel across multiple retailers for at least 12 months.
P5: Attribution	Explained shares rise with verifiable provider-cost records and credible pass-through identification.	Provider accounting data linked to retail prices, demand and concentration.
P6: Transparency burden	Poor disclosure increases verification time, error and mistrust after price is controlled.	Randomised disclosure experiment or task study.
P7: Assessor reliability	Independent assessors apply matching classes and optional evidential states consistently.	Expert vignette study with content validation and inter-rater statistics.

Source: Author's propositions.

No single design can establish market comparability, causal attribution, user burden and normative reliability simultaneously. Validation therefore requires mixed methods, repeated observations and multiple evidentiary authorities.

APPENDIX C. PRELIMINARY OPTIONAL ISLAMIC EVIDENTIAL SCREEN

C1. Status and boundary

This appendix is a preliminary interpretive module and does not form part of HBD. It distinguishes user-perceived acceptability, F_u, from independently verified integrity, F_v. It is not a fatwa, safety certification, regulatory determination or policy rule. The categories require expert content validation, evidence hierarchies and inter-rater testing before they can be used operationally.

The screen uses non-compensable gates because strong performance on price, transparency or affordability cannot cure established substantive non-compliance, material deception or severe harm. The absence of a detected failure is not a Pass. A Pass requires positive, scope-appropriate evidence under a stated authority and for a stated period.

Table C1 presents the evidential gates, materiality anchors and reporting consequences of the preliminary optional screen.

Table C1. Preliminary evidential gates and reporting rules

Element	**Scope or materiality anchor**	**State**	**Reporting rule**
Gate 1: substantive Shariah integrity	Material condition essential to the declared halal or Shariah status; authority, scope and period stated.	Pass / Fail / Not assessable	Any Fail produces a gate-failed output; missing evidence is not a Pass.
Gate 2: assurance against material deception	No material misstatement, omission, hidden charge or concealed term is identified within the defined transaction scope.	Pass / Fail / Not assessable	Pass requires positive disclosure, audit or equivalent evidence appropriate to scope.
Gate 3: assurance against severe or materially avoidable harm	Safety, deprivation, coercion, exploitative risk transfer or comparable serious welfare consequence.	Pass / Fail / Not assessable	State the risk period, materiality threshold and responsible authority.

Stage B substantive direction	Halal-linked value, transparency, proportionality, affordability and accountability.	Favourable / adverse / mixed / neutral / not determined	Report each criterion separately; no weighted total score.
Stage B evidence confidence	Directness, completeness, corroboration, independence and consistency.	High / moderate / low / insufficient	Use a separate consistency flag (consistent/conflicting) rather than combining direction and confidence.
Overall output	Logical result of gate precedence; Stage B cannot offset a failed gate.	Gate-failed / indeterminate / gate-cleared profile	No automatic verdict of lawful, unlawful, fair, excessive or warranting policy intervention.

Source: Author's preliminary construction.

Decision rule: if any gate fails, the output is gate-failed. If no gate fails but at least one gate is Not assessable, the output is indeterminate. A gate-cleared profile requires all three gates to Pass. Stage B then reports the direction of each criterion and the confidence in the supporting evidence separately.

C2. Illustrative application of the decision rule

Table C2 applies the gate-precedence logic to two hypothetical cases and the Tesco snapshot. The scenarios are explanatory only; they do not validate the screen.

Table C2. Illustrative application of the preliminary decision rule

Scenario	**Evidence pattern**	**Permitted output**	**Interpretive limit**
Gate-cleared hypothetical	Independent halal audit within scope; complete ingredient and charge disclosure; current safety evidence; no material contradiction.	All gates Pass; Stage B profile reported.	Does not by itself show that the price difference is proportionate, fair or policy-relevant.
Material-deception hypothetical	Credible evidence establishes a concealed mandatory charge or materially false halal claim.	Gate 2 Fail; overall gate-failed.	Favourable affordability or transparency on other items cannot offset the failure.
Tesco snapshot in this article	Retailer and product pages support observed price and description only; no independent process, deception or harm audit.	No gate fails on the collected evidence, but all remain Not assessable; overall indeterminate.	No conclusion about Shariah integrity, deception, severe harm or fairness.

Source: Author's illustrative vignettes. These examples are not validation evidence.

The Tesco output remains indeterminate because the evidence supports market comparison, not independent verification of religious integrity, deception or harm; descriptive retail records therefore cannot sustain a normative conclusion.

(O-58) ELIMINATING WASTE, EMPOWERING GROWTH: ALIGNING AIRLINE SUSTAINABILITY WITH MUSLIM-FRIENDLY PASSENGER EXPECTATIONS AT TURKISH AIRLINES

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Abstract

The global halal economy increasingly demands not only religiously compliant services but also environmentally responsible practices, yet waste reduction and Muslim-friendly service quality are rarely examined together. Responding to the conference theme of eliminating waste and empowering growth, this study investigates how airline sustainability practices and Muslim-friendly service expectations jointly shape passenger preferences, using Turkish Airlines as a case. A documentary analysis of the carrier's waste disclosure is combined with an exploratory passenger survey of Turkish Airlines passengers resident in Türkiye, analysed through descriptive statistics, interval-estimated reliability analysis, an importance-performance comparison and correlation, with the multivariate tests the design specifies deferred to a full wave. The carrier discloses catering waste without any stated measurement boundary, at a figure approximately 460 times lower than a benchmark estimate obtained by applying IATA industry ratios to the carrier's passenger volume, while reporting its other waste streams with scope, class breakdown and a named reporting line. Three survey results follow. Halal catering is a saturated attribute rather than a differentiator, rated above the importance passengers assign it and carrying too little variance to function in a measurement model. Interpersonal conduct is rated significantly above facility provision, and the shortfall passengers register concentrates in accommodation for prayer. Willingness to pay an environmental premium is concentrated among respondents who find the airline's sustainability communication credible and absent among those who do not. By linking waste reduction to halal service value, the study reframes sustainability as integral to Muslim-friendly hospitality rather than a separate initiative.

Keywords: waste reduction, sustainable aviation, Muslim-friendly tourism, halal services, passenger preferences.

1. Introduction

The global halal travel market has become a mainstream commercial segment, with international Muslim traveller arrivals reaching 176 million in 2024 and projected to reach 245 million by 2030 (Mastercard & CrescentRating, 2025). The industry carrying it has come under binding decarbonisation obligations: Regulation (EU) 2023/2405 requires a minimum sustainable aviation fuel share of 2 per cent at Union airports from 2025, rising to 70 per cent by 2050 (European Union, 2023). Because the obligation attaches to fuel uplifted at Union airports rather than to the operator's nationality, non-EU carriers with dense European networks absorb comparable costs.

Fuel is the most visible sustainability cost but not the one passengers encounter directly. Cabin waste

is. The average passenger generates approximately 0.94 kg per flight, roughly 34 per cent of it untouched food (International Air Transport Association [IATA], 2025). For most airlines halal meals are a special-meal category, ordered in advance and exposed to waste when a declaration is inaccurate. Turkish Airlines does not list halal among its special menus at all, because its standard catering is already halal, while its No Meal option lets passengers decline catering in advance, unloaded portions going to charitable distribution (Turkish Airlines, 2025). One mechanism thus performs waste avoidance and charitable giving at once, mapping onto a tradition in which squandering resources and the claim to honour are incompatible (Grine et al., 2013).

The two literatures that would examine this have developed independently. Airline environmental research finds disclosure scarce and uneven: only Turkish Airlines published sustainability reports among thirteen carriers in Türkiye (Selimoglu & Caliskan, 2018), and thirteen of fourteen reporting airlines stated a waste-reduction goal but only seven measured it (Cowper-Smith & de Grosbois, 2011). Passenger valuation is conditional and partly manufactured by communication (Núñez Alfaro & Chankov, 2022; Neureiter et al., 2024), and stated attitudes often fail to convert into behaviour (Juvan & Dolnicar, 2014). Aycı and Botan (2025) found 43 per cent of 70 passengers of this carrier unaware of key green aviation concepts and about 71 per cent willing to pay more given verifiable transparency. Muslim-friendly research ranks service elements by necessity (Harum et al., 2018), but passenger evidence disturbs that ordering: halal food quality is unrelated to satisfaction while staff dominate (Jeaheng et al., 2020), catering falls in the low-priority quadrant here (Atalık & Arslan, 2009), and crew conduct dominates positive sentiment (Anitsal et al., 2019).

Neither treats the other as a covariate, and of the 36 papers in the proceedings of the 11th World Halal Summit none addresses the airline sector (World Halal Summit, 2025). This study occupies that intersection. Four expectations are examined: environmental awareness (H1) and communication credibility (H2) are positively associated with willingness to pay an environmental premium; Muslim-friendly performance with behavioural intention (H3); and Muslim-friendly importance with a Muslim-friendly premium (H4). H3 also carries a directional expectation at item level, the three converging studies above implying that interpersonal attributes outweigh catering and facility ones. Given the sample obtained, these are exploratory expectations rather than formal tests.

2. Methods

The study combines documentary analysis of the carrier's 2024 and 2025 reports with a cross-sectional survey of 28 items, the 22 attitudinal ones on a five-point Likert scale. A screening item restricts the sample to respondents who flew with the carrier in the preceding 24 months.

Recruitment was by convenience and snowball sampling. The design target of 100 to 150 valid responses was not met, and the shortfall is reported rather than accommodated. Distribution returned 20 submissions, which with a retained pilot test gave an export of 21. Two were removed on criteria fixed before the data were examined: the pilot, and one recording the identical maximum on all attitudinal items. The analytic sample is 19, all resident in Türkiye; the European component of the target population is unrepresented. No finding below is generalisable to Turkish Airlines passengers at large.

Composites average their items after reliability assessment: Cronbach's alpha with 0.70 as the

threshold, Spearman-Brown for two-item constructs, and 95 per cent confidence intervals throughout, point estimates being unstable at this sample size (Feldt et al., 1987). Correlations with outcomes are Spearman. Significance is reported but is not the basis on which any claim rests: the critical value here is a correlation of 0.456, so only large effects are detectable. The importance-performance comparison follows Atalık and Arslan (2009), except that each attribute is positioned against the overall importance composite, giving a ranking of shortfalls. Common-method variance cannot be meaningfully diagnosed at this sample size and remains a limitation. Participation was voluntary and anonymous; the research was supervised and approved by Prof. Alessandra Viviani, University of Siena.

3. Results

3.1 Documentary analysis: the measurement boundary

Turkish Airlines reports catering-related waste of 104.4 tonnes in 2024 and 47.8 tonnes in 2025, against 96.9 million and 57.8 million meals served (Turkish Airlines, 2024, 2025). Although total reported catering waste declined by approximately 54 per cent, waste per reported meal declined by around 23 per cent, from 1.08 to 0.83 grams, so the fall in absolute waste partly reflects the smaller number of meals served, assuming consistent reporting boundaries. More consequential is the order of magnitude. The carrier served catering to 68.6 million passengers in 2025 and reports 47.8 tonnes of food waste, split into 12.8 tonnes domestic and 35.0 tonnes international. The disclosure therefore does carry a geographic breakdown; what it does not define is which waste categories and which stages of the catering process the figure includes. This corresponds to approximately 0.70 grams of reported catering-related waste per catered passenger. Applying the industry ratios of 0.94 kg per passenger and a 34 per cent untouched-food share (IATA, 2025) implies approximately 21,900 tonnes, a factor of roughly 460. That benchmark is indicative only: the IATA figure derives from a limited audit at a single hub and its waste classes may include beverages and packaging, so equivalence with the carrier's food-waste category cannot be assumed. Three sensitivity scenarios show the comparison is not an artefact of the base ratios: halving per-passenger cabin waste gives roughly 11,000 tonnes (230 times); lowering the untouched-food share to 10 per cent gives roughly 6,400 tonnes (135 times); combining both gives roughly 3,200 tonnes (67 times). The discrepancy remains substantial across these scenarios, although they do not establish the actual quantity of waste generated. The point is not that the disclosed figure is wrong but that the reporting definition does not allow it to be interpreted, in contrast to ground and domestic operational waste, which carries a waste-class breakdown and a named ministerial reporting line.

3.2 Sample and reliability

Roughly three quarters of respondents are under 35 and just under half fly once or twice a year. The sample is young, infrequent-flying, domestically resident and self-selected into a questionnaire naming its own topic, biases that should raise rather than depress the scores of interest. Of the six multi-item constructs, four behave as intended; two required re-specification.

Table 1. Construct descriptives and reliability (N = 19). Two-item constructs report Spearman-Brown, longer scales Cronbach's alpha.

Construct	Items	M	SD	Reliability [95% CI]

Environmental awareness	6, 7	3.00	1.28	0.952 [0.872, 0.982]
Communication credibility	8, 9	3.13	1.25	0.813 [0.500, 0.930]
Environmental importance	10	3.05	1.68	n/a
Muslim-friendly importance, revised	20, 21	3.92	1.13	0.947 [0.858, 0.982]
Muslim-friendly performance, revised	13–19	3.80	0.83	0.819 [0.660, 0.920]
Facility sub-scale	13–16	3.49	1.08	0.883 [0.765, 0.950]
Interpersonal sub-scale	17–19	4.23	0.88	0.699 [0.353, 0.875]
Willingness to pay, environmental	22	2.63	1.34	n/a
Willingness to pay, Muslim-friendly	23	2.95	1.35	n/a
Behavioural intention	24, 25	3.84	1.24	0.908 [0.754, 0.965]
Religiously informed consumption	26, 27	4.03	1.14	0.952 [0.873, 0.982]

The halal catering satisfaction item returns a corrected item-total correlation of −0.413: it moves against the construct it was written to measure. Its distribution explains why: a mean of 4.63, SD 0.68, and not one respondent disagreeing. An item on which nobody disagrees has little variance to share, and although the eight-item scale clears the threshold at $\alpha = 0.754$, removing it raises alpha to 0.819. The Muslim-friendly importance construct did fall below it, its two items correlating at 0.118: catering importance correlates with general Muslim-friendly importance at only 0.198 where information accessibility correlates at 0.899. It is re-specified as the mean of the latter two, returning 0.947. Both revisions are post hoc, which limits the weight they bear. A third result follows from the analysis rather than being imposed on it: the scale separates into a facility sub-scale ($\alpha = 0.883$) and an interpersonal sub-scale ($\alpha = 0.699$) correlating at only 0.352. The interpersonal sub-scale sits below the 0.70 threshold and its confidence interval, 0.353 to 0.875, spans most of the usable range; with three items and a sample of this size the coefficient is too imprecise to establish internal consistency. Results using it are reported on that understanding, and confirming the two-dimensional structure is a task for the full wave.

3.3 Where the shortfall sits

Awareness averages 3.00, with 42 per cent disagreeing that they are aware of this carrier's initiatives. Environmental importance shows the instrument's largest dispersion: 47 per cent agree it matters in airline choice and 47 per cent disagree. Twenty-six per cent agree they would pay an environmental premium.

Table 2. Muslim-friendly attributes: performance and shortfall against importance (N = 19)

Attribute	M	SD	% agree	Gap
Qibla direction guidance	3.11	1.33	42	+0.82
Prayer space on long flights	3.37	1.34	42	+0.55
Prayer-time information	3.37	1.26	47	+0.55
Ramadan catering arrangements	4.11	1.10	74	−0.18
Freedom from religious discrimination	4.11	1.33	74	−0.18
Cabin crew cultural sensitivity	4.21	1.08	79	−0.29
Inclusive atmosphere	4.37	0.90	84	−0.45
Halal catering satisfaction	4.63	0.68	89	−0.71

Every positive gap is an act-of-worship facility; every negative gap is catering or interpersonal conduct. Because each gap is computed against the overall importance composite rather than a matched importance rating, these values rank shortfalls and are not measures of unmet need. The comparison under H3 is in the expected direction: the interpersonal sub-scale averages 4.23 against 3.49 for the facility sub-scale (paired $t(18) = 2.85$, $p = 0.011$, $d(z) = 0.65$; Wilcoxon $p = 0.014$). The one matched importance-performance pair reinforces the catering result: importance averages 4.53 against performance 4.63.

3.4 Associations with willingness to pay and intention

Table 3. Spearman correlations with outcome variables (N = 19). * p < .05, ** p < .01, nominal and uncorrected; see text on multiple comparisons.

Construct	WTP, environmental	WTP, Muslim-friendly	Behavioural intention
Environmental awareness	0.54*	0.16	0.31
Communication credibility	0.50*	0.49*	0.49*
Environmental importance	0.42	0.31	0.46*
Muslim-friendly importance (revised)	0.25	0.38	0.56*
Muslim-friendly performance (revised)	0.64**	0.37	0.48*
Facility sub-scale	0.64**	0.30	0.28
Interpersonal sub-scale	0.45	0.35	0.47*
Religiously informed consumption	0.53*	0.57*	0.52*

The observed associations are consistent with H1 and H2, awareness correlating with the environmental premium at 0.54 and credibility at 0.50, and with H3 at 0.48; H4 receives no such support (0.25). These are preliminary patterns, not hypothesis tests. Table 3 reports 24 coefficients, so roughly one nominally significant result would be expected by chance; under a Bonferroni correction the threshold becomes 0.660 and no coefficient survives it. The markers are therefore descriptive rather than inferential, and the pattern as a whole is what the sample can speak to. Two features were not anticipated: Muslim-friendly performance correlates more strongly with the environmental premium (0.64) than with the Muslim-friendly one (0.37), and religiously informed consumption correlates positively with all three outcomes. Neither is evidence for the study's central proposition, since a correlation between self-reported constructs in one instrument is what common method variance produces. One asymmetry is worth noting: respondents rate Muslim-friendly provision as important (3.92) above their willingness to pay for it (2.95), a difference of 0.97 (Wilcoxon $p = 0.007$), whereas the environmental difference is not distinguishable from zero ($p = 0.302$).

3.5 Credibility, method variance and open responses

Among the five respondents scoring 4 or above on the credibility composite the environmental premium averages 3.40, with 60 per cent agreeing; among the ten scoring between 2 and 4 it averages 2.70; among the four scoring at or below 2 it averages 1.50 and none agree. These subgroups contain five, ten and four respondents and cannot support an effect-size estimate, a trend test, or any claim that credibility causes willingness to pay; the ordering is a descriptive feature of this sample that the full wave is designed to examine properly.

Five respondents used the optional open item. Two name a shortfall in religious provision, one asks

for separate seating by gender, which falls outside the constructs measured here, and one names transparent carbon targets, in-flight waste management and filterable halal menus as jointly decisive. The fifth argues that the dispensations Islamic jurisprudence grants the traveller remove any further expectation, which the instrument does not capture: a low rating need not signal unmet demand.

4. Discussion

The clearest result is one the study did not set out to produce. Halal catering is saturated in this sample: the highest-rated attribute, the only one on which no respondent disagrees, rated above the importance its own passengers assign it, and showing so limited variation that it correlates negatively with its own construct. Jeaheng et al. (2020), Atalık and Arslan (2009) and Anitsal et al. (2019) reached compatible conclusions by different methods; these data reach the same place by a fourth route and extend it to Muslim passengers evaluating a majority-Muslim carrier. One possible explanation is that there is no halal option to choose because there is no non-halal default, so halal catering may operate as a precondition rather than a differentiator.

Interpersonal conduct is rated above facility provision in this sample, which locates the registered gap in the cabin rather than the galley or training. Comparison with the only prior passenger-level study of this carrier is instructive: its awareness figure reproduces closely, 43 per cent unaware against 42 per cent here, while the willingness-to-pay figures diverge, 26 per cent against 71 per cent. One possible explanation is conditioning rather than contradiction, their estimate being conditional on transparency while the present item asks unconditionally. This is not tested here, and sampling and instrument differences would account for the divergence equally well; distinguishing them requires an item stating the transparency condition explicitly, which the revised instrument will carry.

What is missing may not be passenger interest but a basis for a settled view: a passenger cannot verify a figure disclosed without a stated measurement definition, but can register that the communication resolves into nothing checkable. Recent evidence underlines what such a definition must settle: Sundin et al. (2026), auditing an airline catering kitchen over 21 working days, recorded 1.39 tonnes of food waste, roughly 89 per cent of it edible, arising in pre-flight production rather than in the cabin. Which stages a catering-waste figure covers is therefore decisive for what it means, and for whether figures from different carriers can be compared at all. The No Meal option joins the two agendas most directly: it reduces uplift at source, it is intelligible as an act rather than a claim, and it sits within the prohibition on israf identified by Grine et al. (2013). Three propositions follow for practice, each a preliminary reading of this pilot rather than a recommendation the data can carry: further investment in halal catering may not move passenger evaluation here; the registered shortfall in prayer accommodation may warrant exploration of potentially low-cost adjustments to information display and cabin procedure, no costing having been attempted; and environmental claims appear unlikely to be paid for by passengers who do not find them credible. Each should be tested on a fuller sample first.

5. Conclusion

The documentary component stands on its own: the carrier reports catering waste with a domestic-international split but without defining which waste categories and process stages the figure covers, while reporting other waste streams with a waste-class breakdown and a named reporting line. That

asymmetry is a finding about disclosure practice rather than about a quantity of waste. The survey component is a pilot and is reported as one. Three preliminary observations emerged, each specific to this sample: halal catering appears saturated rather than differentiating; interpersonal conduct is rated above facility provision, the shortfall concentrating in accommodation for prayer; and stated willingness to pay an environmental premium tended to be higher among respondents who rated the carrier's sustainability communication as more credible. The limitations govern how each reads. A sample of this size cannot support the multivariate design the instrument was built for; no coefficient survives correction for multiple comparisons; the interpersonal sub-scale falls below the reliability threshold; the sample has no European residents and is non-probability, self-selected and young; two constructs were re-specified post hoc; and willingness to pay is stated rather than revealed (Juvan & Dolnicar, 2014). The full study needs an importance item paired with every performance attribute, a transparency-conditioned willingness-to-pay item, European-resident recruitment, and 150 cases at minimum.

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(O-59) RESOLUTION OF DISPUTES IN THE HALAL INDUSTRY THROUGH SHARIAH-COMPLIANT MEDIATION: A PAKISTANI PERSPECTIVE

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Abstract

The halal industry is growing rapidly worldwide. This expansion has created increasingly complex interactions among halal certification bodies, manufacturers, suppliers, testing laboratories, regulators, retailers, importers/exporters, and consumers. These interactions may generate disputes concerning halal status, ingredient traceability, processing and segregation practices, laboratory findings, certification decisions, suspension or withdrawal of certificates, mutual recognition of certification, use or misuse of halal marks, contractual obligations, supply-chain compliance and cross-border recognition of halal certificates. Such disputes may combine Shariah, regulatory, technical and commercial issues. While litigation remains necessary for some matters, particularly public-law and regulatory determinations, mediation may offer a confidential, relationship-preserving, and comparatively expeditious process for disputes that are legally and Shariah capable of settlement.

In Pakistan, the Alternative Dispute Resolution Act, 2017 provides a statutory basis for ADR in the Islamabad Capital Territory, while provincial ADR frameworks provide statutory foundation at the provincial level. Similarly, the Pakistan Halal Authority Act, 2016 is equally relevant because it establishes the federal regulatory architecture for halal articles and processes, including imports and exports. Accordingly, the feasibility of Shariah-compliant mediation in the halal sector should be assessed at the intersection of ADR law, halal regulation, and Shariah principles rather than on the assumption that all halal-related disputes are freely negotiable.

Existing halal industry scholarship and standards primarily address compliance, certification, testing, accreditation, and supply-chain integrity; the structured use of mediation to manage disputes among halal-industry stakeholders remains comparatively underexplored. AAOIFI Shari'ah Standard No. 32 addresses arbitration and may serve as a useful comparator, but it does not establish a mediation framework. The study should therefore avoid treating mediation as inherently superior to arbitration and instead examine where mediation is functionally and normatively appropriate.

In the context of the halal industry, mediability is the central issue. Contractual and commercial disputes concerning payment, performance, service quality, delays, costs, or allocation of responsibility may generally be capable of consensual settlement, whereas questions involving definitive halal/haram determinations, mandatory certification or accreditation requirements, public enforcement, fraud, consumer safety, or rights of third parties may require authoritative Shariah, technical or regulatory determination.

This paper will therefore (i) develop a taxonomy of halal-industry disputes; (ii) identify which categories are legally and Shariah mediable; (iii) identify safeguards for mediators and parties

including informed consent, impartiality, confidentiality, preservation of mandatory legal and Shariah requirements, and access to independent Shariah or technical expertise; and (iv) assess the feasibility of a Shariah-compliant mediation framework for Pakistan with potential relevance to other OIC jurisdictions.

This paper will adopt a qualitative doctrinal and empirical approach. It will examine Pakistani ADR legislation, the Pakistan Halal Authority Act, 2016, relevant OIC/SMIIC halal and conformity-assessment standards, Shariah principles governing sulh, and AAOIFI Shari'ah Standard No. 32 as a comparative reference. Semi-structured interviews will be conducted with a purposive sample of halal industry regulators, certification and accreditation bodies, manufacturers and suppliers, testing laboratories, Shariah scholars, lawyers/mediators, and trade stakeholders. The findings will be thematically analysed to develop a mediability matrix and a proposed mediation protocol specifying referral criteria, mediator competence, use of Shariah/technical experts, confidentiality, settlement boundaries, and interaction with regulatory processes. Rather than presuming the outcome, the study will assess whether and under what conditions such a framework can reduce avoidable litigation, preserve commercial relationships, and strengthen confidence in halal certification and trade.

Keywords: Halal Industry, Pakistan Halal Industry, Dispute Resolution, ADR Act 2017, Mediation and Arbitration, Shariah-compliant Mediation.

(O-60) NUTMEG BETWEEN SPICE AND INTOXICANT: INTEGRATING HANAFI JURISPRUDENCE AND TOXICOLOGICAL EVIDENCE FOR HALAL CERTIFICATION

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Abstract

Nutmeg (Myristica fragrans) is a common culinary spice whose psychoactive effects at high doses create recurring uncertainty in halal certification. This review asks whether contemporary toxicological evidence supports the Hanafi distinction between customary culinary use and quantities that cause intoxication, stupefaction, impairment, or significant harm. A focused qualitative review was undertaken of key Hanafi texts, contemporary Hanafi rulings, dietary exposure data, and clinical and toxicological literature. Hanafi authorities, particularly Ibn ʿĀbidīn and al-Ṭaḥṭāwī, distinguish solid substances such as nutmeg from intoxicating beverages and prohibit the quantity that causes intoxication or harm rather than every minute amount. Scientific evidence shows a marked dose gap: dietary data report a mean nutmeg intake of 0.14 grams per portion and a 97.5th percentile intake of 0.32 grams, whereas intoxication has been reported from about 5 grams and is more consistently associated with larger deliberate exposures. Recent poison-centre data likewise place symptomatic cases in the multi-gram range. The juristic and toxicological evidence therefore converge on a dose-dependent distinction, while not establishing a universal intoxication threshold. For halal certification, nutmeg should not be rejected solely because it is present as a flavouring. Assessment should consider concentration in the finished food, normal serving size, intended use, and reasonably foreseeable consumption. Deliberate use at intoxicating, stupefying, or harmful levels remains prohibited.

Keywords: nutmeg, Hanafi jurisprudence, halal certification, intoxication, toxicology

1. Introduction

Nutmeg is the dried seed kernel of *Myristica fragrans*, an evergreen tree of the Myristicaceae family. It is widely used in baked products, confectionery, sauces, meat dishes, beverages, and spice blends. Mace is a separate spice obtained from the aril surrounding the seed. Nutmeg also contains naturally occurring alkenylbenzenes, including myristicin, elemicin, and safrole, and large ingested quantities can produce neuropsychiatric, cardiovascular, and gastrointestinal effects (Götz et al., 2022).

This creates a practical halal-certification question. Some juristic discussions classify nutmeg among substances capable of impairing or stupefying the intellect, while ordinary food use involves very small quantities added for flavour. Treating every trace amount as equivalent to an intoxicating beverage may therefore overlook both the juristic classification of the substance and the dose at which the relevant effect occurs.

The question is especially important in Hanafi jurisprudence because later Hanafi authorities distinguish between liquid intoxicants and certain solid substances that become intoxicating,

stupefying, or harmful only at higher quantities. The legal analysis consequently turns not only on the identity of nutmeg, but also on quantity, purpose, foreseeable consumption, and effect.

Although the permissibility of small, non-intoxicating quantities of nutmeg is recognised in Hanafi jurisprudence, the application of this principle to modern food manufacturing requires further clarification. Existing juristic rulings establish the conditions of permissibility but do not necessarily provide a structured procedure through which halal certifiers can assess ingredient concentration, serving-size exposure, and the potential for impairment. This study addresses that practical gap by integrating Hanafi legal principles with published dietary and toxicological evidence to propose a preliminary assessment framework for nutmeg-containing food products. The framework does not introduce a new religious ruling or establish a universal safe dose. Its contribution is to translate established juristic principles into identifiable assessment criteria for halal certification.

2. Method

This focused doctrinal and narrative review examines three complementary Hanafi sources: al-Ḥaṣkafī's *al-Durr al-Mukhtār*, Ibn ʿĀbidīn's *Radd al-Muḥtār*, and al-Ṭaḥṭāwī's commentary on *Marāqī al-Falāḥ*. Al-Ḥaṣkafī identifies nutmeg among prohibited mind-affecting substances; Ibn ʿĀbidīn clarifies distinctions between intoxicating liquids and certain solids according to quantity and effect; and al-Ṭaḥṭāwī discusses the permissibility of small, non-intoxicating quantities. Together, these sources present both general prohibitions and qualifications relevant to culinary use.

Contemporary Hanafi rulings were consulted to determine how these texts have been applied to modern food use. The scientific component draws on dietary-exposure research, reviews of nutmeg constituents, clinical literature on intoxication, and recent poison-centre data.

The scientific evidence was examined by distinguishing between studies of ordinary dietary consumption and clinical reports of nutmeg poisoning. Dietary studies, such as Siruguri and Bhat (2015), provide estimates of the quantities of nutmeg consumed in routinely prepared foods but do not directly assess toxicological effects. In contrast, clinical case reports and poison-centre studies, including Reynoard et al. (2019) and Bleisch et al. (2026), document reported exposures and associated symptoms under different circumstances. These findings were compared to identify differences in consumption quantities and their observed effects. However, because retrospective poison-centre studies rely on reported exposures, often involving incomplete dosage information and individual variability, their findings cannot establish the precise quantity of nutmeg at which intoxication begins or determine a universally safe consumption threshold.

The analysis extracted four points from the scientific literature: customary quantity per portion, reported quantities associated with intoxication, the context or purpose of ingestion, and uncertainty in individual response. The juristic analysis focused on classification, quantity, intention, impairment, and harm. The two evidence streams were then compared to determine whether ordinary culinary exposure falls within the circumstances to which the Hanafi prohibition is directed.

3. Evidence

3.1. Culinary and Toxicological Exposure

Measured culinary exposure is small. In a dietary study of routinely prepared foods in southern India,

mean nutmeg intake was 0.14 grams per portion, the 97.5th percentile was 0.32 grams, and the observed range was 0.02 to 0.64 grams (Siruguri & Bhat, 2015). These figures describe nutmeg used as a flavouring within food rather than consumed by itself for a pharmacological effect.

Toxicological reports operate on a very different scale. Intoxication has been reported after ingestion of about 5 grams, although the minimum effective dose is not precisely defined and individual responses vary (Hallström & Thuvander, 1997; Casale et al., 2023). In a retrospective review of 22 cases of nutmeg exposure recorded by the Marseille Poison Control Center between 2008 and 2018, Reynoard et al. (2019) reported that all patients who ingested more than 10 grams of powdered nutmeg experienced symptoms of intoxication, although not all 22 patients were symptomatic. Recent Swiss poison-centre data further demonstrate this variability: among cases with known doses, the median was 10 grams in asymptomatic cases, 18.25 grams in mild cases, and 22.5 grams in moderate cases (Bleisch et al., 2026).

The available scientific evidence demonstrates a substantial difference between customary culinary exposure to nutmeg and the quantities associated with reported intoxication. However, the minimum dose capable of producing intoxicating or harmful effects has not been conclusively established, and individual responses may vary. Consequently, the reported toxicological findings should not be interpreted as establishing a universal safe threshold. Rather, they indicate that ordinary culinary consumption generally involves quantities substantially smaller than those associated with documented cases of intoxication.

Table 1. *Comparison of culinary and reported toxicological exposure to nutmeg*

Context	Approximate nutmeg exposure	Purpose/context	Evidence-based interpretation
Customary culinary use	Mean 0.14 g per portion	Flavouring in prepared food	Culinary intake measured; intoxicating effects not directly assessed
Higher -dose poison-centre cases	More than 10 g powdered nutmeg	Reported human exposures in a retrospective poison-centre study	All patients who consumed more than 10g of powdered nutmeg were symptomatic in reported case series
Lowest reported intoxication	About 5 g	Usually unusual or deliberate ingestion	Symptoms have been reported; response varies
Recent poison-centre cases	Median 18.25 g mild; 22.5 g moderate	Predominantly non-culinary exposure	Demonstrates multi-gram symptomatic exposure and inter-individual variability

Sources: Hallström and Thuvander (1997); Siruguri and Bhat (2015); Casale et al. (2023); Bleisch et al. (2026), Reynoard et al. (2019)

3.2. Hanafi Juristic Framework

The Hanafi literature does not present nutmeg simply as an ordinary intoxicating beverage. Al-Ḥaṣkafī mentions nutmeg among prohibited mind-affecting substances, while the surrounding discussion concerns materials that impair the intellect rather than wine itself (Al-Ḥaṣkafī, 2002). Ibn ʿĀbidīn explains that the description of such substances as intoxicating can refer broadly to covering or impairing the intellect and notes their character as mukhaddir, or stupefying substances. He then distinguishes the intoxicating quantity from the small quantity, stating that the amount producing intoxication is prohibited while the small amount is not treated identically (Ibn ʿĀbidīn, 1992, p. 458).

Al-Ṭaḥṭāwī makes the qualification more explicit. After reporting a claim that nutmeg is prohibited by

consensus, he indicates that this can be understood as referring to the state in which intoxication occurs. He then records the Hanafi position that a small quantity of substances other than wine and comparable beverages is not prohibited when it does not intoxicate (Al-Ṭaḥṭāwī, 1997).

Ibn ʿĀbidīn's discussion is directly relevant to nutmeg, as he expressly mentions *jawzat al-ṭīb* (nutmeg) when commenting on al-Ḥaṣkafī's statement of prohibition. His analysis distinguishes between different effects on the intellect. The term *muskir* refers to a substance that causes intoxication or obscures the intellect, while *mukhaddir* describes a substance that produces stupor or dulling of the faculties without necessarily causing exhilaration. The term *mufattir* refers to a substance that produces languor or bodily weakness, as mentioned in the prophetic report concerning intoxicating and enervating substances (Abū Dāwūd, no. 3686). These descriptions may overlap rather than represent entirely separate legal categories. Ibn ʿĀbidīn distinguishes the prohibited intoxicating or harmful quantities of certain solid substances from small quantities used for legitimate purposes without impairment (*Radd al-Muḥtār*, 6:455–459). Al-Ṭaḥṭāwī (1997) further clarifies the permissibility of small, non-intoxicating quantities of nutmeg.

This reading also explains why the prophetic principle that whatever intoxicates in a large quantity is prohibited in a small quantity is not applied by these later Hanafi authorities to every solid substance in the same manner as intoxicating liquids. Ibn ʿĀbidīn's discussion expressly distinguishes substances such as nutmeg and opium and notes that small quantities may have legitimate medicinal or other uses, while the intoxicating or harmful amount remains prohibited (Ibn ʿĀbidīn, 1992).

3.3. Contemporary Hanafi Application

Contemporary Hanafi rulings largely preserve this dose-and-effect distinction. Nutmeg is permitted as food or medicine when the amount is not intoxicating (Rabbani, 2010). Darul Uloom Deoband similarly permits a non-intoxicating quantity and cites Ibn ʿĀbidīn as its basis (Darul Ifta, Darul Uloom Deoband, 2016). Darul Ifta Birmingham likewise permits nutmeg in food when the quantity does not intoxicate and it is not used with the intention of becoming intoxicated (Badat, 2022). These rulings do not amount to unrestricted permission; they preserve prohibition where the substance is deliberately used to intoxicate, stupefy, or cause harm.

4. Discussion

The juristic and scientific evidence converge at one central point: dose and effect matter. The legal literature distinguishes a small amount used for a legitimate purpose from the amount that produces intoxication or impairment, while the scientific literature shows that customary culinary exposure is generally measured in fractions of a gram and reported intoxication in grams. This does not make toxicology the source of the legal rule; rather, toxicology helps determine whether the factual condition to which the rule is applied is present in ordinary food use.

The strongest scientific point is the scale difference. The mean culinary exposure reported by Siruguri and Bhat is approximately one thirty-sixth of 5 grams, and even the 97.5th percentile exposure is approximately one sixteenth of that amount. The comparison should not be converted into a rigid legal or medical threshold because the minimum effective dose is uncertain, products differ, and individual susceptibility varies. Nevertheless, it materially weakens an argument that the presence of a customary flavouring quantity is pharmacologically equivalent to deliberate high-dose ingestion.

Published toxicological assessments provide further context for interpreting the differences between customary culinary exposure and reported intoxication. Hallström and Thuvander (1997) considered adverse effects from estimated ordinary dietary exposure to myristicin unlikely, although they acknowledged limitations in the available safety evidence. More recent evaluations by Götz et al. (2022) and the German Federal Institute for Risk Assessment (2022) identified continuing uncertainties concerning the toxicological properties of myristicin and elemicin, particularly their potential long-term effects. These assessments support a distinction between the low likelihood of acute intoxication at customary culinary exposures and the broader question of toxicological safety, which remains incompletely resolved.

In food, nutmeg is dispersed through recipes for flavour, whereas many poisoning cases involve direct or unusually concentrated ingestion for psychoactive effects. Quantity and intended use therefore remain relevant to the Hanafi assessment.

For halal certification, the appropriate question is consequently not simply whether nutmeg appears on an ingredient list. Certification should assess the quantity in the finished product and the amount likely to be consumed. A product containing a customary flavouring quantity may be materially different from a concentrated preparation, supplement, extract, or product designed or marketed for psychoactive effect. The analysis should also consider cumulative exposure where a product is plausibly consumed in multiple servings.

4.1. Proposed Certification Framework

Under the Hanafi interpretation examined in this study, the presence of nutmeg in a food product does not automatically render that product impermissible. Equally, its use as a flavouring does not, by itself, establish permissibility. The relevant considerations are the quantity consumed, its intended use, and whether customary or reasonably foreseeable consumption produces intoxication, stupefaction, impairment, or significant harm.

Based on the preceding juristic and toxicological analysis, Table 2 presents a proposed assessment procedure for halal certification bodies evaluating products containing nutmeg. The framework considers the ingredient's intended use, quantity, potential effects, and relevant Hanafi legal principles.

Table 2. *Proposed halal-certification assessment framework for nutmeg*

Assessment factor	Certification question	Practical implication
Amount and concentration	How much nutmeg is present in the finished product? What form is it in? What is the purpose for its use	Customary flavouring levels are treated differently from concentrated preparations.
Serving exposure	How much nutmeg is consumed in a normal serving and in reasonably foreseeable multiple servings?	Assessment should reflect actual consumption, not ingredient presence alone.
Function and intention	Is nutmeg used for flavour, or is the product intended or marketed for psychoactive effect?	Ordinary culinary use supports permissibility; psychoactive use does not.
Effect and uncertainty	Could foreseeable use plausibly cause intoxication, stupefaction, impairment, or significant harm?	Proceed under ordinary certification procedures where justified, request specialist review where uncertain, or withhold certification where prohibited use is established.

4.2. Limitations

This review has limitations. It is a focused narrative review and does not claim to identify every juristic text or toxicological report. Culinary-intake data are drawn from a specific dietary population and may not represent all cuisines or industrial formulations. Clinical reports are heterogeneous, and the relationship between whole nutmeg, individual constituents, body weight, co-ingestants, and symptoms remains incompletely defined.

The absence of reported acute intoxicating effects at customary culinary exposures should not be interpreted as proof of safety across all toxicological endpoints. The available scientific literature contains uncertainties concerning the long-term effects of certain naturally occurring nutmeg constituents. Consequently, the present analysis is primarily concerned with the relationship between consumption quantity and acute impairment relevant to the Hanafi juristic discussion. It does not replace a comprehensive toxicological risk assessment.

The proposed halal-certification framework has not yet been independently validated by specialists in Hanafi jurisprudence and toxicology or tested in practical certification settings. It should therefore be regarded as a preliminary assessment tool rather than a definitive certification standard. Further expert evaluation and practical application are recommended to establish its reliability and suitability for use by halal-certification bodies.

5. Conclusion

The Hanafi treatment of nutmeg is best understood as a distinction between ordinary, non-intoxicating use and consumption that produces intoxication, stupefaction, impairment, or significant harm. Contemporary toxicological evidence is consistent with the practical basis of that distinction: customary culinary exposure is generally measured in fractions of a gram, whereas reported intoxication is associated with multi-gram ingestion and remains subject to individual variability. Nevertheless, the available evidence does not establish a universally safe consumption threshold, and the permissibility of nutmeg under the Hanafi approach must therefore be considered in relation to the quantity consumed, its effects, and the circumstances of its use.

For halal certification, the mere presence of nutmeg as a minor flavouring should therefore not automatically render a food impermissible under this Hanafi approach. The certifier should consider concentration, serving size, intended function, and reasonably foreseeable consumption. Concentrated or deliberate use for psychoactive effect falls outside ordinary culinary use and remains prohibited. This approach retains the juristic concern for preservation of the intellect while applying it to the actual dose and use conditions found in modern food production.

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(O-61) VALUE-BASED HALAL INDUSTRY: FROM HALAL BUSINESS TO HALAL INDUSTRY

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Abstract

The halal industry encompasses a broad range of sectors, including food, tourism, logistics, pharmaceuticals, cosmetics, media, and finance, and has evolved into an increasingly diverse and multifaceted industry. The growth of the global halal industry is driven by several key factors, including the expanding Muslim population, growing consumer awareness of halal products and services, and increasing and evolving consumer demand. However, a significant body of literature on the halal industry focuses on the compliance of products and services with Islamic principles, production processes, halal standards, and certification practices. At the same time, a growing body of research examines halal business practices through the lenses of business ethics, corporate values, social responsibility, and sustainability. Halal business can be described as firm-level activities conducted in accordance with Islamic principles. Building on this perspective, the present study proposes a new value-based conceptual positioning of the halal industry by linking it to the concept of "Halal business" and moving beyond existing definitions of the Halal industry.

A comprehensive literature review was conducted, drawing upon findings and evidence from relevant research to establish the conceptual foundation of the study. Based on this literature, the study proposes conceptualizing the Halal industry as a value-based corporate and economic system. In this framework, a value-based management approach entails the adoption, implementation, and institutionalization of core values—including justice, trust, equality, human dignity, stakeholder engagement, social responsibility, and sustainability—within organizational structures and practices. The integration of these values into business operations is important for keeping employee well-being, upholding human dignity, strengthening environmental responsibility, and supporting social development. Accordingly, the study positions Halal business as a foundational component through which value-based principles can be embedded within the broader Halal industry.

This study offers a new perspective to the literature by examining the relationship between Halal business and the halal industry from a value-based perspective. It is intended to provide a conceptual reference for academics and researchers in the field. Furthermore, it is expected to assist business managers across various sectors, particularly within the Halal industry, in developing and implementing value-based management practices.

Keywords: Halal Industry, Halal Business, Values

(O-62) THE ROLE OF RELIGIOSITY, HALAL KNOWLEDGE, AND SUSTAINABILITY PRACTICES TOWARDS HALAL SUPPLY CHAIN INTEGRITY AMONG EMPLOYEES IN HALAL FOOD INDUSTRY IN BRUNEI DARUSSALAM

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Abstract

The knowledge about halal supply chain integrity and sustainability are still limited in Brunei. To achieve Brunei Vision 2035, the role of human resource management is inevitable in this subject. The study aimed to examine and collaborate the role of religiosity, halal knowledge, and sustainability practices towards halal supply chain integrity among employees in halal food industry in Brunei Darussalam. This study employed mixed methods: quantitative and qualitative methods. Participants from employees in halal food companies in Brunei filled online self-administered questionnaires. Other participants from owners or managers of halal food companies, halal experts, and related government officers were interviewed. To avail the findings, IBM SPSS 29 was used to do pilot study and Smart PLS 4.0 was used for inferential analysis to test research hypotheses, and thematic content analysis for qualitative findings. The study showed that religiosity was found not to be a significant catalyst towards halal supply chain integrity among employees. However, halal knowledge and sustainability practices were found to significantly affect halal supply chain integrity among employees in halal food industry in Brunei. Furthermore, the study suggested that halal knowledge among employees should be enhanced through halal training. It is also recommended that sustainability practices should be strengthened through written policy and coordination among government institutions to reduce Brunei's carbon footprint and dependency on other countries. Finally, the study then suggested that Brunei may improve its capability to incorporate technology and people to its halal supply chain integrity. Hence, the entire supply chain in halal food industry can ensure the halalan thayyiban from farm-to-fork.

Keywords: Religiosity, Halal Knowledge, Sustainability, Halal Supply Chain, Halal Food, Employee Management, Brunei Vision 2035

1. Introduction

The halal food industry has developed into an important component of the global halal economy. Halal does not only concern the final status of a food product but also encompasses processes involving sourcing, production, handling, storage, transportation, and distribution.

Therefore, halal integrity needs to be maintained throughout the supply chain. Wilson (2014) explains that halal has developed beyond a narrow religious classification and increasingly represents a broader system involving values, standards, quality, and ethical considerations.

In the context of Brunei Darussalam, the development of the halal food industry is particularly relevant to national economic diversification and Brunei Vision 2035. The country's Islamic identity,

regulatory environment, and commitment to economic diversification provide an important setting for the development of halal-related businesses. Nevertheless, challenges remain in relation to halal logistics, supply-chain integration, employee awareness, and understanding of halal requirements. Previous research has highlighted the continuing need to strengthen halal supply chain management in Brunei and other small halal markets (Ab Talib & Zulfakar, 2024).

Halal supply chain integrity refers to the preservation of halal status throughout the supply chain. It requires organizations to ensure that halal products remain protected from contamination, inappropriate handling, and contact with non-halal materials. Maintaining such integrity requires not only organizational systems but also competent human resources. Employees are directly involved in many operational activities that may affect halal status, making their knowledge, behaviour, and practices important to the implementation of halal requirements.

One factor potentially associated with employee behaviour is religiosity. Religiosity refers to the extent to which religious beliefs and values influence an individual's behaviour and daily activities (Souiden & Rani, 2015). In halal-related research, religiosity has frequently been examined in relation to consumers' attitudes, intentions, and purchasing behaviour. However, relatively less attention has been given to employees who are responsible for implementing halal requirements within organizations. This creates an important research gap because employees' daily actions can directly influence halal integrity.

Halal knowledge represents another important factor. Knowledge concerning halal requirements, certified ingredients, segregation procedures, halal assurance systems, and relevant standards may assist employees in implementing halal practices correctly. Rajendran et al. (2024) demonstrate the relevance of halal knowledge and human capital to halal supply chain integrity, particularly in halal-related businesses.

In addition, sustainability has become increasingly relevant to halal supply chain management. Sustainability involves maintaining an appropriate balance among economic, environmental, and social considerations over time (Costanza & Patten, 1995). Within the halal industry, sustainable practices may include waste reduction, responsible resource use, ethical sourcing, environmentally friendly materials, and appropriate operational policies. Previous studies have demonstrated the relationship between sustainability and halal supply chain management (Ab Talib & Zulfakar, 2024; Khan et al., 2022).

Although previous studies have investigated halal supply chain integrity, Islamic human capital, and sustainable halal supply chain management, few have simultaneously examined religiosity, halal knowledge, sustainability practices, and halal supply chain integrity among employees. Rajendran et al. (2024) examined halal supply chain integrity and Islamic human capital, while Ab Talib and Zulfakar (2024) focused on sustainable halal food supply chain management. Sari et al. (2024) examined sustainable strategic planning and management in halal culinary businesses. The present study extends this literature by combining the three explanatory variables and examining employees in the halal food industry in Brunei Darussalam.

Accordingly, this study aims to:

1.examine the influence of religiosity on halal supply chain integrity;

2.determine the effect of halal knowledge on halal supply chain integrity; and 3.examine the impact of sustainability practices on halal supply chain integrity among employees in the halal food industry in Brunei Darussalam.

2. Literature Review and Hypotheses

2.1 Religiosity and Halal Supply Chain Integrity

Religiosity describes the extent to which religious beliefs and values influence an individual's attitudes and behaviour. In Islamic contexts, religious values may guide ethical decisions and daily practices, including decisions concerning food and business activities (Souiden & Rani, 2015). Within a halal organization, religiosity may theoretically encourage employees to comply with halal principles because halal requirements are not viewed merely as organizational procedures but also as religious obligations.

However, religiosity does not necessarily translate directly into workplace behaviour.

Employees may comply with halal requirements because of organizational policies, certification requirements, training, supervision, or legal obligations. Thus, the relationship between religiosity and halal supply chain integrity requires empirical examination, particularly among employees rather than consumers.

H1: Religiosity has a significant effect on halal supply chain integrity among employees in the halal food industry in Brunei Darussalam.

2.2 Halal Knowledge and Halal Supply Chain Integrity

Halal knowledge includes employees' understanding of halal requirements, certified ingredients, halal assurance procedures, segregation, handling, and other practices required to preserve halal status. Human capital and knowledge are important resources for organizations because employees need appropriate competencies to implement organizational procedures effectively.

Rajendran et al. (2024) highlighted the relevance of Islamic human capital and halal supply chain integrity in halal businesses. Similarly, Karia and Assari (2015) emphasized that halal organizations depend on appropriate knowledge and resources to support halal management practices.

Employees who understand halal requirements may be better equipped to identify potential risks, verify suppliers, maintain segregation, and respond appropriately to changes in ingredients or procedures. Therefore, halal knowledge is expected to contribute positively to halal supply chain integrity.

H2: Halal knowledge has a significant positive effect on halal supply chain integrity among employees in the halal food industry in Brunei Darussalam.

2.3 Sustainability Practices and Halal Supply Chain Integrity

Sustainability concerns the ability of systems and organizations to maintain their activities over time while balancing economic and environmental considerations (Costanza & Patten, 1995).

In halal supply chains, sustainability can be reflected through waste management, resource efficiency, responsible sourcing, environmentally friendly materials, and policies supporting ethical business

practices.

Ab Talib and Zulfakar (2024) emphasize the importance of sustainable halal food supply chain management, while Khan et al. (2022) identify relationships between halal supply chain management and sustainability. Sari et al. (2024) further demonstrate the relevance of sustainable strategic planning and management within halal culinary businesses.

Sustainability practices can support halal integrity by encouraging systematic management, responsible sourcing, appropriate handling, and efficient use of resources. Consequently, sustainability is expected to have a positive relationship with halal supply chain integrity.

H3: Sustainability practices have a significant positive effect on halal supply chain integrity among employees in the halal food industry in Brunei Darussalam.

3. Methodology

3.1 Research Design

This study employed a mixed-methods research design combining quantitative and qualitative approaches. The quantitative component was used to examine the relationships between religiosity, halal knowledge, sustainability practices, and halal supply chain integrity. The qualitative component provided additional insights into how halal requirements and related practices are implemented within the industry.

3.2 Participants and Data Collection

The quantitative component involved 150 employees working in halal food companies in Brunei Darussalam. Respondents included staff, supervisors, managerial employees, and business owners. Of the respondents, 46.67% were staff, 20% were supervisors, 19.33% were in managerial positions, and 14% were owners. In terms of business type, 66.67% worked in restaurants, 25.33% in food manufacturing, and 8% in food retail.

The qualitative component involved seven participants comprising relevant halal experts, government representatives, owners, and managers from the halal food industry. The qualitative interviews explored employees' religiosity, halal knowledge, sustainability practices, common halal-related challenges, and mechanisms for maintaining halal supply chain integrity.

3.3 Measurement and Data Analysis

The questionnaire used a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The study measured four constructs: religiosity, halal knowledge, sustainability practices, and halal supply chain integrity. The measurement items for religiosity, halal knowledge, and halal supply chain integrity were adapted primarily from Rajendran et al. (2024), while sustainability indicators were derived from Ab Talib and Zulfakar (2024) and Sari et al.

(2024).

The quantitative data were analyzed using Microsoft Excel for descriptive statistics, IBM SPSS for preliminary analysis, and SmartPLS 4.0 for partial least squares structural equation modeling (PLS-SEM). PLS-SEM was selected to assess the relationships among the latent constructs and test the proposed hypotheses. Bootstrapping was conducted at a 5% significance level (Hair et al., 2017).

Qualitative interview data were analyzed using thematic analysis.

4. Results

4.1 Descriptive Findings

The descriptive results indicated relatively high levels across the four research constructs.

The grand mean for religiosity was 4.50, indicating a high level of reported religiosity among respondents. The highest religiosity item concerned fear and hope motivating respondents to remain on a righteous path, with a mean of 4.74. The lowest item concerned motivation through daily or weekly *tazkirah*, with a mean of 3.85.

The grand mean for halal knowledge was 4.66. This indicates that respondents generally perceived their organizations as having strong halal knowledge and related practices. However, periodic internal audits represented one of the comparatively lower-rated items, suggesting that continuous internal monitoring may still require strengthening.

Sustainability practices recorded a grand mean of 4.42. Waste and resource-efficiency practices received the highest rating, whereas the use of environmentally friendly materials received a comparatively lower rating. This suggests that sustainability within the participating organizations may be more developed in relation to resource and waste management than environmentally friendly materials.

Halal supply chain integrity recorded a grand mean of 4.62. The highest-rated item concerned the segregation of halal and non-halal products to prevent cross-contamination, with a mean of 4.77. In contrast, sending workers for halal food-handling training recorded a comparatively lower mean of approximately 4.45.

4.2 Measurement Model

The measurement model demonstrated acceptable levels of internal consistency and convergent validity for the study constructs. Cronbach's alpha values were 0.66 for religiosity, 0.64 for halal knowledge, 0.63 for sustainability, and 0.61 for halal supply chain integrity. Composite reliability values ranged from 0.62 to 0.66, while average variance extracted values ranged from

0.50 to 0.55.

4.3 Structural Model

Relationship	f^2	p-value	Result
Religiosity → Halal Supply Chain Integrity	0.009	0.387	Not significant
Halal Knowledge → Halal Supply Chain Integrity	0.188	0.000	Significant
Sustainability → Halal Supply Chain Integrity	0.278	0.000	Significant

The structural model produced different results for the three hypothesized relationships.

The results show that religiosity did not have a statistically significant effect on halal supply chain integrity ($f^2 = 0.009$, $p = 0.387$). Therefore, H1 was not supported. In contrast, halal knowledge had a statistically significant positive effect on halal supply chain integrity ($f^2 = 0.188$, $p = 0.000$), supporting H2. This finding is consistent with Rajendran et al. (2024), who emphasized the

importance of halal-related human capital and knowledge for halal supply chain integrity. It is also consistent with Karia and Assari (2015), who highlighted the importance of knowledge resources for halal management practices.

Sustainability practices also had a statistically significant positive effect on halal supply chain integrity ($f^2 = 0.278$, $p < .001$), supporting H3. This finding is consistent with previous research emphasizing the relationship between sustainable practices and halal supply chain management (Ab Talib & Zulfakar, 2024; Khan et al., 2022).

The coefficient of determination (R^2) was 0.469, indicating that religiosity, halal knowledge, and sustainability practices collectively explained 46.9% of the variance in halal supply chain integrity. The remaining 53.1% may be associated with other factors not included in the model.

5. Qualitative Findings and Discussion

The qualitative findings provide additional explanations for the quantitative results.

Although religiosity was reported as important within the halal environment, participants indicated that compliance with halal requirements may also be driven by organizational regulations, certification requirements, training, supervision, and personal responsibility. One important observation was that employees may follow halal instructions because they are required to comply with organizational or regulatory procedures rather than solely because of their personal religious motivation. This provides a possible explanation for why the quantitative relationship between religiosity and halal supply chain integrity was not statistically significant.

The findings also suggest that religious commitment alone may not guarantee consistent operational compliance. In a halal food environment, employees need practical knowledge concerning ingredients, suppliers, contamination risks, *najis*, *sertu*, halal certification, segregation, and food-handling procedures. Therefore, religiosity may provide an ethical or motivational foundation, whereas formal knowledge and organizational systems may be necessary to translate these values into consistent workplace practices.

The strong effect of halal knowledge is further supported by qualitative evidence.

Participants identified challenges involving unfamiliar halal logos, changes in ingredients, supplier verification, halal certificates, segregation, and employees' understanding of halal procedures.

Some organizations addressed these issues by maintaining halal files, appointing halal administrators, conducting supplier checks, providing halal training, and establishing dedicated halal areas and transportation.

The findings suggest that knowledge should not be limited to obtaining halal certification.

Continuous internal training is necessary because employees are directly involved in operational activities. The dissertation findings particularly indicate the need to strengthen employee training and internal halal knowledge rather than relying exclusively on external certification processes.

Sustainability also emerged as an important component of halal supply chain integrity.

Several organizations reported practices involving waste management, resource efficiency, responsible sourcing, food safety, and environmental initiatives. However, the level of sustainability varied among

organizations. Some businesses had more structured sustainability practices, while others continued to rely on conventional waste disposal and plastic packaging.

This finding is consistent with the literature suggesting that sustainability and halal supply chain management are interconnected (Ab Talib & Zulfakar, 2024; Khan et al., 2022).

Sustainability should therefore be understood not only as an environmental concern but also as part of responsible and systematic halal business management.

The qualitative findings further indicate that technology remains an area for development.

Some businesses use digital communication and documentation to coordinate with suppliers, but advanced traceability technologies are not yet widespread. Previous research has highlighted the potential of technologies such as the Internet of Things for improving traceability and transparency in halal food supply chains (Rejeb et al., 2021). Greater integration of technology with employee knowledge and organizational procedures could strengthen traceability from upstream suppliers to downstream consumers.

6. Conclusion

This study examined the effects of religiosity, halal knowledge, and sustainability practices on halal supply chain integrity among employees in the halal food industry in Brunei Darussalam.

The findings demonstrate that the three factors do not have identical relationships with halal supply chain integrity.

Although respondents reported a high level of religiosity, religiosity did not demonstrate a statistically significant effect on halal supply chain integrity. This finding indicates that religious commitment alone may not be sufficient to explain differences in organizational halal integrity.

Workplace compliance may also depend on formal requirements, knowledge, training, supervision, organizational policies, and regulatory mechanisms.

Halal knowledge demonstrated a significant positive effect on halal supply chain integrity.

This finding emphasizes the importance of employee competence and understanding in implementing halal requirements. Employees need practical knowledge concerning halal ingredients, supplier verification, segregation, contamination prevention, halal certification, and food-handling procedures.

Sustainability practices also demonstrated a significant positive effect. The result supports the view that sustainable practices can contribute to systematic and responsible halal supply chain management. Sustainability initiatives involving resource efficiency, waste management, ethical sourcing, environmental awareness, and organizational policies can complement halal assurance practices.

Overall, the model explained 46.9% of the variance in halal supply chain integrity. The findings contribute to halal supply chain literature by examining employees rather than focusing exclusively on consumers and by bringing religiosity, halal knowledge, and sustainability practices together within one empirical framework.

7. Practical Implications

Several practical implications can be derived from the findings. First, halal food companies should

strengthen continuous halal training for employees. Training should cover not only basic halal concepts but also practical issues such as ingredient verification, halal certification, contamination prevention, segregation, *najis*, *sertu*, supplier verification, and halal assurance procedures.

Second, organizations should strengthen internal halal monitoring. Written halal policies, internal audits, halal documentation, and clear responsibilities for halal administrators can help translate halal requirements into daily operational practices.

Third, sustainability should be incorporated into organizational policies. Companies can strengthen waste management, resource efficiency, responsible sourcing, environmentally friendly materials, and employee awareness of environmental impacts. Coordination among relevant government institutions may also help organizations develop more consistent sustainability practices.

Finally, technology can be incorporated more systematically into halal supply chain management. Digital documentation, traceability systems, supplier databases, and emerging technologies such as the Internet of Things could improve visibility and monitoring throughout the halal supply chain (Rejeb et al., 2021).

8. Limitations and Future Research

This study has several limitations. First, the quantitative sample consisted of 150 employees in halal food companies in Brunei Darussalam. Therefore, future studies could use larger samples and include a broader range of halal industry sectors.

Second, the study focused on three explanatory variables. The model explained 46.9% of the variance in halal supply chain integrity, indicating that other factors may also contribute to halal integrity. Future research could examine variables such as ethical awareness, organizational culture, halal leadership, employee competency, regulatory compliance, internal control, and technological readiness.

Third, the study focused primarily on employees. Future studies could compare employees, managers, suppliers, regulators, and consumers to provide a more comprehensive understanding of halal supply chain integrity.

Finally, longitudinal research could examine how employee training, organizational policies, and sustainability initiatives influence halal supply chain integrity over time.

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(O-63) TOWARDS A CIRCULAR HALAL ECONOMY: A SHARIAH-COMPLIANT FRAMEWORK FOR WASTE REDUCTION AND RESOURCE RECOVERY IN HALAL FOOD SUPPLY CHAINS

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Abstract

The continued growth of the Halal food industry has drawn greater attention to food loss, inefficient resource use, packaging waste, processing by-products, and environmental pressures across complex supply chains. Circular economy practices offer practical ways to reduce waste while recovering value from resources that might otherwise be discarded. However, their application within Halal food supply chains remains underexplored, particularly when resource recovery must meet both sustainability goals and Shariah requirements. This study proposes a Shariah-compliant circular economy framework for waste reduction and responsible resource recovery across Halal food supply chains.

The study adopts a qualitative conceptual approach, drawing on a structured review and thematic analysis of recent literature on Halal supply chain management, circular economy practices, food waste, resource recovery, and relevant Islamic principles. Attention is given to principles concerning consumption, waste, purity, segregation, and the use of by-products. The proposed framework integrates three interconnected dimensions: Halal integrity and Shariah compliance, circular resource management, and sustainable value creation.

The framework shows how waste prevention, reduction, recovery, recycling, and value creation from permissible by-products can be integrated into Halal supply chain practices without compromising Halal integrity. It also highlights Shariah compliance as a governance dimension often overlooked in conventional circular economy models. By connecting circular practices with Halal requirements, the study provides a practical foundation for producers, certification bodies, policymakers, and supply chain stakeholders to reduce resource losses, strengthen sustainability, and create economic value from recoverable resources, thereby supporting responsible resource use and sustainable growth.

Keywords: Circular Halal Economy; Halal Food Supply Chain; Waste Reduction; Resource Recovery; Shariah Compliance;

1. Introduction

The Halal food industry is a complex, global system with its supply, processing, packaging, storage and transport, distribution and retail segments. In this system, the Halal requirements are not limited to the permissibility of the final product but are applied all along the supply chain (Soon et al., 2017; Tieman et al., 2012). Meanwhile, there is an increasing awareness of food loss and waste, of inefficient use of natural resources, of packaging waste, of processing by-products and of environmental pressures, which have all made food production and food supply chain management

(Papargyropoulou et al., 2014; Rejeb et al., 2021). increasingly dependent on more sustainable methods. There is an important challenge for the Halal food sector which is how to improve the efficiency of the resources and make the environment more sustainable without compromising Shariah compliance and the integrity of the Halal food. The concept of the circular economy is applicable to this challenge.

The circular economy model could be described as a shift from the traditional linear economy of extracting, producing, consuming and discarding resources. (Ouro-Salim & Guarnieri, 2022). In the food supply chains, this can be by way of waste prevention and reduction, better use of raw materials, recycling, recovery of resources, better use of suitable by-products in the food production process, and packaging. These practices can minimize environmental costs, generate economic benefits and enhance the overall efficiency of the resources (Santagata et al., 2021). However, when these practices are applied to Halal food supply chains, (Ab Rashid et al., 2018; Soon et al., 2017; Tieman et al., 2012). there are factors that go beyond environmental and economic analyses. One material which is technically recoverable or recyclable is not necessarily suitable for reintegration into a Halal supply chain. The source, purity, contact with prohibited or impure substances, processing, segregation, traceability and purpose may impact its Shariah status. This means that resource recovery in a Halal system must not only be considered in terms of its circular value, but also when it comes to maintaining the Halal integrity during the recovery and re-use process. This is in line with other Islamic principles for the responsible use of resources. Islam forbids wastage and excess (israf) and promotes sensible use of resources and consumption. These are the principles that support ethical approaches to waste reduction and resource use. However, the requirements for Halal, purity, contamination and allowable use are still very important and must not be excluded from the permissible practice just because it is environmentally friendly. Thus, a circular Halal economy needs to be adopted with a proper Shariah governance structure in place that allows the sustainability goals to be embedded within it. Some existing research has investigated the implementation of CE in food systems, such as food waste management, packaging, recycling, resource recovery and valorization of by-products. In parallel research, the focus has been on Halal certification and traceability, segregation, logistics, governance and the preservation of the Halal integrity. The connection between these two fields, however, is not that well developed, especially in terms of recovery and re-cycling of resources and by-products (Ouro-Salim & Guarnieri, 2022; Papargyropoulou et al., 2014; Santagata et al., 2021).while remaining Shariah compliant. This results in the demand for an integrated approach where circular resource management is linked to the different needs of Halal food supply chains. Therefore, this study is intended to design a Shariah-based reduction of waste and responsible recovery of resources model in Halal food supply chain. Structured review and thematic analysis of existing literature provide the interconnections of three dimensions: Halal Integrity and Shariah Compliance, (Soon et al., 2017; Tieman et al., 2012; Zulfakar et al., 2014). Circular Resource Management, and Sustainable Value Creation. By doing so, it aims to offer conceptual and practical guidance for producers, Halal certification bodies, policy makers and stakeholders in the supply chain to facilitate the adoption of circular economy practices in the context of the religious, ethical and operational integrity of Halal food systems. (Rejeb et al., 2021)

2. Methods

2.1. Research Design

The qualitative conceptual research design was selected in this study, with a view to create a Shariah compatible framework for waste reduction and resource recovery, in the context of Halal food supply chains. Thematic analysis was used in conjunction with a structured literature review to gather literature from three thematic areas, namely, Halal supply chain management, circular economy and resource recovery, and Islamically relevant literature. A conceptual approach was deemed suitable as the study was not to test causal relationships or a pre-determined hypothesis, but rather existing knowledge, identification of recurring concepts and integration of these concepts into the context of Halal food supply chains. This also enabled the incorporation of circular economy practices with the specific conditions of Shariah requirements that emerge at the point of recovery and return of materials, waste streams and by-products back to productive use.

2.2. Literature Search and Selection

A systematic literature review was conducted to identify studies related to the study of Halal food supply chain, circular economy, food loss and waste, sustainable supply chain management, resource recovery, recycling, by-products utilization and integrity of Halal food. The search terms were combinations of the following words: Halal supply chain, Halal integrity, circular economy, food waste, resource recovery, food by-products, waste valorization, sustainable food supply chain, traceability, and Halal sustainability. Peer reviewed research papers, which had a direct link to food chains, circular resource management, sustainability or Halal governance, were given priority. Emphasis was placed on recent publications, in order to reflect current developments in circular economy and sustainable food systems. Previous studies that gave basic concepts regarding the integrity of halal supply chain and/or circular economy theory were kept. Publications that did not have a clear connection to the research question or which had only a tangential connection to food supply chains, resource management, or Halal requirements were not included. These included relevant Islamic sources and scholarly discussions to find principles applicable to resource use and recovery. Special focus was paid to israf (wastefulness and excess), responsible consumption, purity and impurity, contamination and segregation, distinction between permissible and prohibited resources and beneficial use of resources. The Shariah considerations of circular practices were done from the perspective of these principles.

2.3. Thematic Analysis

Thematic analysis was used to examine the selected literature. Recurring concepts and relationships were identified, compared and arranged following their relevance in relation to the research goal. The analysis was based on two main questions:

(1) what are the circular economy practices that are relevant in reducing waste and recovering resources in Halal supply chains,

(2) what are the Shariah considerations that dictate whether these practices can be applied without compromising the Halal integrity? The identified themes were then progressively organized into three broad dimensions namely Halal Integrity and Shariah Compliance, Circular Resource Management, and Sustainable Value Creation. The first dimension is the Shariah status of the materials, purity, risk of contamination, segregation, traceability and governance. The second is related to the prevention, reduction, reuse, recycling, recovery and the productive use of products that may be permitted as waste. The third relates to the wider benefits, environmental, economic, in terms of sustainability that can come from responsible circular practices.

2.4. Framework Development

The relationships between the themes identified in the three dimensions were mapped and the framework was developed. The assessment of circular practices was done from two complementary viewpoints: their ability to prevent loss of resources or recover value; and their compatibility with Shariah and Halal requirements. It was therefore important to focus on the origin and composition of materials recovered, their Shariah status, contamination risks, processing or transformation, segregation, traceability, and intended use. The governance foundation is Halal Integrity and Shariah Compliance, the pathway is Circular Resource Management, and the outcome is Sustainable Value Creation. Here, the concept of Shariah compliance is not considered as a post-selection procedure following a circular selection. Instead, it is applied as an overall principle in the use and distribution of resources. The resulting framework offers a structured basis to review and assess waste reduction and resource recovery opportunities and serve as a non-compromising guideline for better resource efficiency and sustainability without affecting the Halal integrity.

3. Results

The thematic analysis showed that the value chain of Halal food cannot be understood by considering waste hierarchy, resource efficiency alone, or by considering its circular economy application. The literature reviewed and Shariah considerations revealed three interdependent dimensions:

(1) Halal Integrity and Shariah Compliance,

(2) Circular Resource Management, and

(3) Sustainable Value Creation. These dimensions are related to each other but also are sequential. (Ab Rashid et al., 2018; Tieman et al., 2012; Zulfakar et al., 2014).The boundaries for resources movement are set by shariah compliance, while resources may be kept in productive use by circular resource management; sustainable value creation is achieved by circular resource management practices that meet the requirements of shariah compliance. Thus, it can be concluded that there is a key finding that the assessment of recoverability and Halal suitability are two different assessments. Technically, a material may be recoverable, but not suitable for reintegration in a Halal value chain due to its origin, its level of contamination, the processing conditions and the next use.

3.1. Halal Integrity and Shariah Compliance

The first dimension was manifested as the dominant layer of the framework. When making the decision on whether a residual material, recovered material or by-product can be kept in or returned to a Halal value chain, eight considerations were identified as particularly relevant: source, composition, Shariah status, purity, contamination history, segregation, processing or transformation, and intended use.

Traceability is a cross-cut when it comes to these considerations because knowing the information about the material is required for determining what its status is in the next stage. Based on the analysis, circular materials can be assumed for three general scenarios. The first is to use materials that are sourced from acceptable sources, and maintain a Halal integrity. These are the simplest to be reused or recovered, provided that there are no basic safety or quality issues. The second is materials whose original source is acceptable, but later processing may result in contact with, mixing or cross-

contamination with non-Halal or impure materials. These need extra control, particularly segregation, handling documentation, cleaning, if applicable, and traceability.

The third case is with materials which have a substantive Shariah question due to its source, contamination history, or its processing. If it is technologically possible to recover such materials, this does not automatically mean that it is Shariah approved for re-entering the Halal supply chain; there must be a Shariah assessment. It is an important boundary to circularity that material recovery is not a given in a Halal system, but something that has to be achieved. Therefore, rather than just virgin raw materials and final products, the halal assurance needs to be expanded to include recovered inputs and secondary material flows.

3.2. Circular Resource Management

The second dimension is related to the operational management of the materials after determining their Halal suitability. The five main circular strategies identified were prevention, reduction, reuse, recycling and recovery, with disposal as the last resort. The resulting hierarchy is: Prevent waste of materials; reduce the amount of waste generated; reuse materials; recycle materials; recover materials; and dispose of materials. (Papargyropoulou et al., 2014).

The hierarchy is a representation of differences in the level of material value that remains. Prevention is always the top priority as there will be fewer handling and recovery needs after any materials are spared of unnecessary use or loss of food. Reduction is achieved by various means: better forecasting, inventory control, storage, transportation, production efficiencies, portion management and package optimization. If there are materials left over, re-use should be considered before more resource intensive types of re-use and/or re-use or recovery, unless there is any risk to safety or compromising the integrity of the Halal product. (Ouro-Salim & Guarnieri, 2022; Santagata et al., 2021).When direct reuse is not possible, recycling and recovery are relevant. Processing residues and by-products may also be diverted towards alternative productive uses instead of disposal as long as it is possible according to their characteristics, safety, quality and Shariah attributes.

This hierarchy, however, indicated that it cannot stand as a self-contained technical sequence. For every transition the proposed circular alternative should be subject to the Shariah conditions outlined in Section 3.1. As such, a higher ranked circular option may not be better if the Halal-integrity risk of the option is unacceptable. In such situations, it may be better to use a lower ranked but Shariah compliant option.

3.3. Sustainable Value Creation

The third dimension reflects the value created because of Shariah compliant circular management of resources. Three main axes of values were found: environment, economy and social/ethical value. Environmental value correlates with minimisation of waste, better use of raw materials, consumption of fewer resources for disposal and keeping resources within the productive cycles. Economic value can come from decreased material losses and disposal costs, efficient operations, and the ability to turn an appropriate by-product into a valuable byproduct or an input to a function. Social and ethical value is focused on responsible consumption and production, avoiding unnecessary waste and the better integration of sustainability initiatives with Islamic values of responsible use of resources. (Rejeb et al., 2021).

The analysis also suggests that these values should not be separated from the concepts of Halal integrity. In the proposed framework, an initiative cannot be considered as fully sustainable if it brings only benefits to the environment and/or economy, but with unacceptable Shariah and/or Halal-integrity risk.

3.4. Proposed Shariah-Governed Circular Halal Economy Framework

The synthesis of the three dimensions resulted in a five-stage decision framework for managing residual materials and resource recovery in Halal food supply chains.

Stage 1: Resource Identification and Characterization.

The process begins with identifying the material under consideration and establishing its source, composition, previous use, point of generation, and current position in the supply chain. This stage distinguishes avoidable waste from unavoidable residues and identifies whether the material may have further productive value.

Stage 2: Shariah and Halal Integrity Assessment.

The material is assessed for permissibility, purity, contamination history, segregation, processing or transformation, traceability, and intended subsequent use. Where the available information is insufficient to determine its status, the material should not proceed automatically to reintegration; further verification or Shariah assessment is required.

Stage 3: Circular Strategy Selection.

For materials considered suitable for further utilization, the highest feasible option within the circular hierarchy is selected: prevention, reduction, reuse, recycling, or recovery. The choice is based not simply on technical feasibility but on the combined requirements of Halal integrity, safety, practicality, and resource efficiency. Disposal is reserved for materials for which no safe, permissible, and reasonable productive option remains.

Stage 4: Halal Assurance during Circular Flow.

Halal integrity must continue to be protected during collection, segregation, storage, transportation, processing, recovery, and reintegration. Appropriate control measures include documented material identity, physical segregation where required, contamination controls, traceability records, suitable handling procedures, and Shariah oversight in cases involving uncertainty or complex transformation. This stage effectively extends Halal assurance from the conventional linear supply chain to secondary and circular material flows.

Stage 5: Sustainable Value Evaluation and Review.

The selected practice is evaluated in terms of resource savings, waste reduction, economic value, and social-ethical benefit, while continued Halal integrity remains a non-negotiable condition. Outcomes are then fed back into sourcing, production planning, waste prevention, and recovery decisions. This feedback mechanism allows the framework to function as a continuous improvement cycle rather than a one-time screening procedure.

The relationship between the three dimensions can therefore be expressed as:

Shariah Governance and Halal Integrity

↓

Resource Identification and Assessment

↓

Prevent → Reduce → Reuse → Recycle → Recover → Dispose

↓

Halal Assurance throughout Circular Flow

↓

Environmental + Economic + Social-Ethical Value

↓

Monitoring, Review and Continuous Improvement

The framework makes two distinctions that are central to the study. First, technical circularity does not by itself establish Halal suitability. Second, Shariah compliance is not an end-stage certification check but a governing condition that operates throughout the resource cycle. The proposed framework therefore brings circular resource management within the logic of Halal assurance and provides a structured basis for deciding not only whether a resource can be recovered, but whether it should be recovered, how it may be used, and under what conditions it can legitimately return to a Halal value chain.

4. Discussion

The results indicate that the implementation of circular economy principles to Halal food supply chains is not just about implementing the conventional waste management practices. It calls for a transition to stewarding resources under Shariah which involves assessing the continued circulation of materials not only on environmental performance and economic value, but also on their Shariah status and preservation of Halal integrity. This separation is crucial for food systems, where leftover materials and by-products can undergo multiple collection, handling, processing, transformation, and re-use cycles before they are returned to productive use. This proposed framework therefore adds an important dimension to traditional circularity: a material can be technically recovered but not be suitable to reintegrate it in a Halal value chain. In a Halal context, resource recovery is not just about technical feasibility or resource efficiency. Permissibility and integrity of material should be kept in the decision throughout the circular journey.

4.1. Shariah Compliance as a Governance Dimension

One of the key contributions of the framework is the concept that while technical recoverability is important, it does not necessarily mean Shariah suitability. In the conventional circular systems, decisions of re-use, re-cycle or recovery are frequently based on environmental performance, technical feasibility and economic value. (Soon et al., 2017; Tieman et al., 2012)

These considerations are still relevant in Halal food supply chains, but not enough. The quality or source of retrieved materials, the presence of prohibited or impure materials, processing or transformation, segregation, traceability and intended use can all impact the materials' appropriateness

for reintegrating them into a Halal system. This distinction is significant for the Halal assurance issue. Circular resource flows can generate new instances of primary products, residual materials, recycled inputs and by-products interacting. It is likely, therefore, that current Halal assurance systems need to be broadened to include the mobilisation and reintegration of recovered resources. Where materials pass through various stages or organizations, traceability, segregation, documentation, contamination control and proper Shariah control become very significant. (Ab Rashid et al., 2018)

4.2. Circularity and Islamic Resource Ethics

The framework also places circular resource management within the broader ethical context of Islamic teachings on consumption and the use of resources. The avoidance of *israf* (wastefulness and excess), responsible consumption, and the beneficial use of resources provide a normative basis for reducing avoidable losses and seeking legitimate uses for materials that retain value. (Qur'an 7:31)

This ethical relationship, however, requires an important qualification. The objective of preventing waste does not make every form of reuse or recovery acceptable. Environmental benefit, cost reduction, or technological capability cannot independently determine Shariah permissibility. Where a recovered material involves prohibited sources, impurity, cross-contamination, or uncertainty concerning its transformation and subsequent use, the relevant Shariah considerations remain decisive.

The framework therefore avoids presenting circularity as an objective to be maximized without qualification. Instead, it proposes responsible circularity within Shariah boundaries. This approach brings together two concerns that are sometimes addressed separately: avoiding unnecessary loss of beneficial resources and protecting the integrity of Halal products and processes.

4.3. Practical Implications for Halal Food Supply Chains

The proposed framework has direct implications for Halal food producers. Waste and by-product management can be incorporated into Halal assurance at the design stage rather than being treated solely as an environmental issue after production. Producers may identify where losses arise, determine which residual materials retain productive value, and assess whether those materials can be safely and permissibly reused, recycled, recovered, or directed towards other applications.

For Halal certification and auditing bodies, circular material flows may require a broader understanding of the scope of Halal assurance. Recovered inputs, recycled materials, processing by-products, shared recovery facilities, storage arrangements, transportation, and cross-contamination pathways may become relevant audit considerations. (Tieman et al., 2012; Zulfakar et al., 2014).

This does not necessarily require every recovered material to be treated identically; rather, the level of control should reflect the material's source, risk profile, processing history, and intended use.

The framework also points to the value of interdisciplinary assessment. Certain cases cannot be resolved through Shariah analysis or technical assessment in isolation. Food scientists may determine the nature and transformation of a material, supply chain specialists may establish its movement and traceability, and Shariah experts may evaluate the implications of those facts for permissibility and Halal integrity. Collaboration among these disciplines is therefore particularly important in complex cases involving transformation, contamination, or novel recovery technologies.

For policymakers and industry bodies, the framework offers a basis for developing sustainability

initiatives that do not treat environmental performance and Halal compliance as parallel and unrelated objectives. Integrating them at the level of material flows may support both resource efficiency and confidence in Halal systems.

4.4. Contribution, Limitations, and Future Research

This study contributes to the emerging literature on sustainable Halal supply chains by linking circular economy strategies with Shariah governance within a single conceptual framework. Its principal contribution is the integration of Halal Integrity and Shariah Compliance, Circular Resource Management, and Sustainable Value Creation, thereby extending the conventional understanding of circularity to account for the distinctive requirements of Halal food systems.

The study is nevertheless conceptual and therefore has limitations. The proposed framework has not yet been empirically validated within specific industries, firms, or geographical contexts. Waste streams and Shariah considerations may differ considerably across meat processing, dairy production, food manufacturing, agriculture, packaging, and other segments of the Halal food sector. Future research should therefore test the framework through case studies, expert interviews, industry surveys, and comparative sectoral analysis. Further work could also develop measurable indicators for Halal-compliant circularity and examine how digital traceability technologies can support the monitoring of recovered resources.

Overall, the findings indicate that circular economy practices and Halal requirements should not be treated as competing objectives. When Shariah compliance is incorporated into resource-management decisions from the outset, circular strategies can contribute simultaneously to waste reduction, resource efficiency, economic value creation, environmental responsibility, and the preservation of Halal integrity.

4.5. Limitations and Future Research

The framework remains conceptual and has not yet been empirically validated within specific firms, industries, or geographical settings. Its application may vary considerably across different segments of the Halal food industry. Meat and poultry processing, for example, may present different questions of by-product utilization and contamination from those encountered in dairy production, food manufacturing, agricultural processing, or packaging systems. Regulatory requirements and Halal standards may also differ across jurisdictions.

Future research should therefore test and refine the framework through case studies, interviews with Shariah scholars and Halal auditors, industry surveys, and sector-specific applications. Particular attention could be given to identifying measurable indicators for Shariah-compliant circularity and establishing practical criteria for classifying recovered materials according to their Halal-integrity risk. Further research could also examine how digital traceability, supply chain data systems, and other emerging technologies can support the verification of circular material flows.

Overall, the study suggests that circularity and Halal integrity need not be competing objectives, but neither should they be assumed to be automatically compatible. Their effective integration depends on appropriate Shariah governance throughout the resource cycle. By embedding Halal assessment, traceability, segregation, and assurance within circular resource management, the proposed framework offers a pathway for reducing waste and recovering value while maintaining the religious and

operational integrity upon which Halal food systems depend.

5. Conclusion

This study set out to examine how circular economy practices can be applied to waste reduction and resource recovery in Halal food supply chains without compromising Shariah requirements. The findings show that circularity in a Halal context cannot be judged solely by whether a material can be recovered, recycled, or put to another productive use. Its source, composition, purity, contamination history, processing, segregation, traceability, and intended use are equally important in determining whether it can legitimately remain within, or return to, a Halal value chain.

To address this issue, the study proposes a Shariah-Governed Circular Halal Economy Framework built around three interconnected dimensions: Halal Integrity and Shariah Compliance, Circular Resource Management, and Sustainable Value Creation. The framework places Shariah governance at the center of circular decision-making and follows a clear resource hierarchy: prevent, reduce, reuse, recycle, recover, and, only where necessary, dispose. Importantly, Halal assurance does not end once a material has been approved for recovery; it continues through handling, processing, movement, and reintegration into the supply chain.

The key contribution of the study lies in distinguishing technical recoverability from Shariah suitability.

Materials may be technically recoverable and economically valuable yet still be unsuitable for a Halal system. At the same time, materials that remain permissible, safe, traceable, and suitable for further use should not necessarily be treated as waste. Their responsible recovery can conserve resources, reduce unnecessary disposal, improve operational efficiency, and create environmental, economic, and social-ethical value.

The framework offers a practical starting point for Halal food producers, certification bodies, policymakers, and supply chain professionals seeking to incorporate circular practices into Halal operations. As the framework is conceptual, however, its practical value will ultimately depend on how it performs in real supply chains. Future research should therefore test and refine the framework across different Halal food sectors, develop measurable indicators for Shariah-compliant circularity, and examine how traceability technologies can support the verification of recovered material flows.

A circular Halal economy should therefore be understood not simply as an economy that produces less waste, but as one that uses responsibly, preserves their value wherever legitimately possible, and maintains Halal integrity throughout the resource cycle. Bringing these objectives together offers a practical path towards a Halal food system that is more efficient, environmentally responsible, economically productive, and firmly grounded in Shariah principles.

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(O-64) BRIDGING THE REGULATORY GAP: HARMONIZING WAQF GOVERNANCE AND HALAL CERTIFICATION REGIMES ACROSS OIC MEMBER STATES

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Abstract

This study examines how institutional fragmentation between waqf governance authorities and halal certification bodies across Organisation of Islamic Cooperation (OIC) member states constrains the integration of Islamic social finance into halal industry development, with the objective of identifying the specific forms this fragmentation takes and proposing a graduated regulatory harmonization pathway, anchored in each jurisdiction's own primary legal instruments, capable of closing this gap without requiring uniform legal reform across very different institutional starting points. To this end, a qualitative comparative institutional analysis was conducted using primary legal instruments, including national waqf statutes, halal certification acts, royal decrees, and implementing regulations, together with secondary academic literature from six representative OIC jurisdictions selected to maximize variation in legal tradition and institutional maturity: Indonesia, Malaysia, Saudi Arabia, Türkiye, Pakistan, and Nigeria, with documents analysed through systematic thematic coding to identify regulatory fragmentation typologies and institutional coordination mechanisms. The results show that four regulatory fragmentation typologies characterize the waqf-halal interface: structural siloing, where waqf and halal governance answer to entirely separate ministries with no coordination mechanism, as in Saudi Arabia and Türkiye; mandate overlapping, where the two functions share a ministry but lack a joint statutory mandate, as in Indonesia and Malaysia; standards divergence, compounded by a federal-provincial jurisdictional split, as in Pakistan; and structural absence, where no coherent statutory basis exists for either domain, as in Nigeria. Building on this typology, the study proposes the Waqf-Halal Regulatory Harmonization (WAHRAH) Roadmap, comprising three graduated stages, domestic regulatory alignment, mutual recognition, and cross-border regulatory interoperability, with institutional mechanisms, enabling conditions, and indicative timelines anchored to each country's existing legal architecture. On this basis, waqf authorities, halal certification and accreditation bodies, and Islamic economic policymakers across OIC member states should adopt inter-agency coordination protocols, unified reporting standards, and enabling legislative amendments to progress through the WAHRAH stages, with the Standards and Metrology Institute for Islamic Countries (SMIIC) identified as the natural cross-border anchor for the roadmap's most advanced stage.

Keywords: halal certification, regulatory harmonization, waqf governance, institutional fragmentation

ACADEMIC SECTION 2: POSTER PRESENTATIONS

(P-01) ISLAMIC ZERO WASTE HIERARCHY: A SHARIAH FRAMEWORK FOR REFUSE, REDUCE, REUSE, RECYCLE, AND REGENERATE IN HALAL

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Abstract

The rapid expansion of the global Halal industry has increased the need to address not only Halal compliance, food safety, and hygiene, but also resource consumption, industrial waste, packaging, by-product utilization, and environmental responsibility across the value chain. This study develops an Islamic Zero Waste Hierarchy grounded in the Qur'an, Sunnah, and Islamic jurisprudence, and examines its practical relevance to contemporary Halal industry operations.

The study adopts a qualitative normative and analytical methodology. Relevant Qur'anic verses, Ahadiths (Sunnah), and jurisprudential principles from the Hanafi, Maliki, Shafi'i, and Hanbali schools are selected according to their direct relevance to resource conservation, prevention of waste, material utilization, transformation, and ecological regeneration. These sources are analysed and mapped onto five principles: Refuse, Reduce, Reuse, Recycle, and Regenerate. Refuse and Reduce are examined through the prohibition of Israf and Tabdhir and the principle of moderation. Reuse is illustrated through Prophetic practices of repairing personal belongings and utilizing the hide of a dead animal. Recycle is examined through the jurisprudential doctrine of Istihalah, while Regenerate is linked to the Qur'anic concept of Mizan and Sunnah encouragement of cultivation and productive stewardship of land.

The framework is applied to practical challenges within the Halal industry. For example, Refuse and Reduce can address unnecessary single-use packaging and excessive water consumption in food processing and slaughter operations. Reuse can encourage the repair and extended use of equipment and suitable packaging systems. Recycle can guide the recovery and beneficial utilization of slaughterhouse by-products, food-processing residues, and other recoverable materials, subject to Shariah requirements. Regenerate can support composting of suitable organic residues and the return of nutrients to agricultural production.

The findings indicate that the Islamic Zero Waste Hierarchy provides a clear Shariah framework for integrating resource efficiency, waste diversion, by-product utilization, and environmental responsibility into Halal management and conformity systems. It connects sustainable industrial practice with Maqasid al-Shari'ah, particularly the prevention of harm and protection of life and wealth. The framework offers a practical bridge between Shariah principles and contemporary circular economy approaches, strengthening the environmental dimension of Tayyib within the evolving Halal industry.

Keywords: Halal Industry, Shariah, Islamic Zero Waste, Circular Economy, Maqasid al-Shari'ah

(P-02) BEYOND COMPLIANCE: A HALAL CIRCULARITY ASSURANCE FRAMEWORK FOR ELIMINATING WASTE AND EMPOWERING GROWTH

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Abstract

The global Halal economy has developed increasingly sophisticated systems for determining product permissibility, protecting identity, certifying conformity, and accrediting competent bodies. Yet the prevention, classification, recovery, and verifiable circulation of waste, surplus, by-products, and transformed materials remain weakly integrated into mainstream Halal assurance. This conceptual paper argues that sustainability is not an external ethical supplement to Halal compliance. The Qur'anic norms of halal and tayyib, the prohibition of israf, the balance of mizan, the trust of amanah, and the prevention of harm support a life-cycle responsibility that must nevertheless remain disciplined by authoritative Shariah determinations. Using an integrative conceptual synthesis of Islamic jurisprudential principles, Halal quality-infrastructure standards, circular-economy scholarship, and conformity-assessment practice, the paper develops the Halal Circularity Assurance Framework (H-CAF). H-CAF contains seven sequential assurance gates: authority and scope; material-flow mapping; prevention; segregation and identity preservation; Shariah determination of recovery options; evidence-based market re-entry; and verified impact. Three supporting instruments are proposed: a Shariah Material Status Register, a Halal Circularity Passport, and a 100-point Halal Circularity Assurance Performance (H-CAP) score. A defining design rule is non-compensability: environmental gains cannot offset a critical Halal-integrity failure, and circularity cannot legalize a prohibited, contaminated, doubtful, or insufficiently transformed material. Standards mapping shows how H-CAF could interface with OIC/SMIIC Halal food, certification, accreditation, quality-management and supply-chain standards; ISO 59004, ISO 59010 and ISO 59020; life-cycle assessment; and laboratory and conformity-assessment infrastructure. The paper concludes with propositions and a 180-day, multi-country pilot research agenda. H-CAF is presented as a testable conceptual architecture—not as an adopted standard—to support prevention-first design, lawful value recovery, credible claims, resilient value networks, and future harmonization of the sustainable Halal economy.

Keywords: Halal circular economy; Halal assurance; waste prevention; Shariah governance; accreditation; material-flow traceability; circularity measurement; Istihalah; sustainable Halal economy

(P-03) VALORISATION OF AGRI-FOOD BY-PRODUCTS TO SUPPORT A CIRCULAR HALAL ECONOMY

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Abstract

The valorisation of agri-food by-products offers an important pathway for reducing food system waste while producing value added ingredients for a sustainable halal economy. However, circularity alone does not guarantee halal integrity or tayyib quality. This study critically examines the technological opportunities and halal conformity considerations associated with converting cereal, fruit, vegetable, oilseed, and other processing by-products into dietary fibre, protein, pectin, bioactive compounds, and functional powder ingredients. Particular attention is given to potential halal critical points in recovery processes involving extraction, fermentation, enzymatic treatment, separation, drying, and particle engineering. These points include the origin and traceability of raw materials; the halal status of enzymes, microorganisms, fermentation media, solvents, processing aids, and carrier agents; cross-contamination in shared facilities; and compositional changes occurring during processing. Representative valorisation routes, including protein recovery from wheat germ, oilseed meals, and surplus bakery products, as well as the production of pectin and dietary fibre from fruit and vegetable residues, are considered to illustrate the integration of food engineering with halal assurance. A halal-by-design framework is proposed in which traceability, risk-based ingredient assessment, process control, analytical verification, resource efficiency, and product functionality are addressed from the initial development stage. This integrated approach could facilitate the safe recirculation of agri-food resources, increase the economic value of processing by-products, and strengthen consumer confidence in sustainable halal products. Aligning circular processing technologies with halal and tayyib principles can therefore support waste reduction, responsible production, and innovation across the halal food value chain.

Keywords: Agri-Food By-Products, Circular Halal Economy, Halal-By-Design, By-Product Valorisation, Sustainable Food Systems

(P-04) INTEGRATING OIC/SMIIC HALAL STANDARDS WITH ISLAMIC FINANCE INSTITUTIONS: A SHARIAH FRAMEWORK FOR HALAL INDUSTRY EXPANSION

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Abstract

The global halal industry is expanding beyond food into pharmaceuticals, cosmetics, tourism, services, raw materials, and other sectors. However, halal conformity of products and services and Shariah compliance of their financing are generally addressed through separate systems. This paper proposes an integrated framework linking OIC/SMIIC halal standards with Islamic banking and finance transactions to establish a more comprehensive halal industry ecosystem.

The study examines how relevant OIC/SMIIC halal standards can be incorporated into the financing, investment, and monitoring processes of Islamic financial institutions. The proposed framework considers major Islamic finance structures, including Murabahah, Musharakah, Ijarah, Istisna', and other applicable Shariah-compliant transactions, and explores their practical linkage with halal conformity requirements. Under this approach, financing eligibility would consider not only the Shariah-compliant nature of the financial transaction but also the halal conformity of the financed product, service, production process, raw materials, and related operations, where applicable.

The framework further proposes greater coordination among halal certification bodies, halal testing laboratories, halal authorities, Islamic financial institutions, Shariah experts, technical experts, and financial professionals. OIC/SMIIC standards for areas such as halal food, pharmaceuticals, cosmetics, tourism, services, and raw materials can provide objective technical and Shariah-based conformity criteria, while Islamic finance mechanisms can provide structured and Shariah-compliant financial support to enterprises meeting such requirements.

Such integration can strengthen the halal services sector by creating new areas of professional collaboration, employment, and specialized expertise across conformity assessment, laboratory testing, certification, Shariah governance, technical assessment, financial structuring, and related services. It can also facilitate the emergence of new professional opportunities and service models within the expanding halal economy.

The paper argues that integrating these two dimensions can create a more coherent halal value chain, strengthen confidence among consumers and investors, improve traceability and governance, and facilitate the development of halal enterprises across sectors and jurisdictions. The proposed model positions halal conformity and Islamic financing as interconnected components of a broader halal economic ecosystem, providing a basis for further standardization, institutional cooperation, service development, and sustainable growth of the global halal industry.

Keywords: Halal; Finance; Standards; Shariah; Integration

ACADEMIC SECTION 3: INVITED SPEAKERS

(I-01) HALAL ASSESSMENT AND VALORIZATION OF FOOD INDUSTRY WASTE: WHICH WASTE STREAMS CAN BE REUSED?

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Abstract

The food industry generates large amounts of waste and by-products from various activities, including animal slaughtering, farming, dairy processing, and food manufacturing. Many of these materials can be recovered and reused in food, feed, pharmaceutical, cosmetic, and other industries, contributing to waste reduction and the circular economy. However, their reuse raises important questions regarding their halal status.

This study aims to identify and classify the major waste streams generated by the food industry, examine their current and potential industrial applications, and assess their halal status. Particular attention is given to slaughterhouse by-products, such as blood, bones, fats, and internal organs; agricultural waste, including crop residues and animal manure; and dairy by-products, such as whey and cheese-processing residues.

The study evaluates these materials based on their origin, processing methods, possible contamination, and relevant Shariah requirements. It also identifies materials that are inherently halal, those that are prohibited, and those that may become permissible under specific conditions, including appropriate sourcing, processing, and purification.

The findings aim to provide a practical framework for evaluating the halal suitability of food industry waste streams and identifying opportunities for their safe and sustainable valorization. This approach supports zero-waste initiatives while ensuring compliance with halal requirements.

Keywords: Halal, Food Industry Waste, Waste Valorization, Slaughterhouse By-products, Dairy Waste, Circular Economy, Zero Waste.

(I-02) ZERO WASTE PERSPECTIVE ON GAS WASTES AND GREENHOUSE GAS EMISSIONS

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Abstract

The conventional linear waste management approach, which mainly relies on landfilling, open burning, and incineration, treats carbon as waste to be disposed of and accounts for about 3–5% of global greenhouse gas (GHG) emissions. Since municipal solid waste (MSW) generation is expected to reach an estimated 3.8 billion tonnes per year by 2050, moving toward a circular bioeconomy is essential to avoid severe climate consequences. This article examines the shift from the current disposal-based system to a zero-waste approach that focuses on the valorization of organic wastes. By applying circular strategies and removing organic waste from landfills, the sector can offset 30% to 39% of its projected emissions in 2050. Moving beyond simple energy recovery via anaerobic digestion, advanced biorefineries combine biotechnological processes such as anaerobic digestion, composting, and fermentation to transform organic waste into high-value bioproducts like microbial proteins, biopolymers (PLA, PHA), and platform chemicals (lactic and volatile fatty acids). Life-cycle assessments (LCA) show that recovering carbon in a high-value way results in significant net climate benefits, achieving negative net carbon footprints (for example, −58 to −147 kg CO2-eq/t biopulp for microbial proteins). Lastly, for circular biowaste systems to be operationally successful and gain social acceptance, they must incorporate ethical and cultural frameworks and digital traceability (HAS, MS 1900) to build community trust and promote public acceptance of upcycled products. Ultimately, incorporating multi-product biorefineries into strong socio-ethical policies offers a scalable, net-zero solution for global waste management.

Keywords: Biogas, biorefinery, composting, greenhouse gases, landfilling, life cycle assessment, zero-waste

1. Conventional Waste Management Systems as Greenhouse Gas Emitters

Humanity uses natural resources 1.7 times faster than the planet can regenerate them, creating an ecological deficit that accelerates global climate change by increasing greenhouse gas (GHG) emissions (Lin et al., 2018). The waste sector is one of the major contributors, accounting for 3-5% of global GHG emissions (Gautam & Agrawal, 2021; Ijimdiya et al., 2026; Zandieh et al., 2024). Typical activities in the current waste management system, including transportation, landfilling, incineration, and/or open burning, emit large amounts of methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O) into the atmosphere (Gautam & Agrawal, 2021; Yang et al., 2024; Zandieh et al., 2024). Among the current waste management routes, landfills remain the highest-emitting pathway. For example, in the UK, landfilled waste accounts for about 70% of the sector's emissions (Yang et al., 2024; Zandieh et al., 2024). This linear management system not only produces direct GHG emissions, but also increases overall climate impact by wasting the energy, land, water, and carbon bound in products throughout their lifecycles (Blair & Mataraarachchi, 2021; Lane et al., 2023). Especially, landfilling of

the organic fraction of municipal solid waste (OFMSW) clearly highlights this problem by emitting local methane during its anaerobic decomposition and also losing valuable nutrients (Blair & Mataraarachchi, 2021; Lane et al., 2023).

In the future, the amount of municipal solid waste (MSW) generated annually is expected to reach between 3.5 and 3.8 billion tonnes by 2050 (Gautam & Agrawal, 2021; Ijimdiya et al., 2026; Yang et al., 2024). If there are no fundamental changes in the disposal-centered waste management system, this growing volume of waste will lead to a dramatic increase in climate impacts. In contrast, the circular economy model serves as a feasible alternative to the current linear model by focusing on waste elimination, material recycling, and ecosystem restoration (Ijimdiya et al., 2026; Yang et al., 2022). Studies show that incorporating circular strategies into regional waste systems could reduce the expected rise in emissions by 30 to 39% by 2050 (Ijimdiya et al., 2026; Yang et al., 2022). This decrease is driven by storing organic wastes away from disposal sites/landfills, improving material reuse and recycling, reducing energy requirements at earlier stages of the supply chain, and recovering value from organic waste streams. Nowadays, innovative routes, such as converting organic waste streams into platform chemicals, biopolymers/bioplastics, and/or proteins, are gaining great attention to valorize the carbon content of the waste streams (Ijimdiya et al., 2026).

From the standpoint of achieving a zero-waste outcome, the main issue is not merely the total quantity of waste; rather, it lies in our continued reliance on a disposal-based system that treats recoverable carbon as a liability rather than an asset. For the waste sector to achieve global net-zero targets, it needs a fundamental shift in approach, prioritizing source separation, waste prevention, recycling, resource recovery, and circular product design over landfill disposal (Awino & Apitz, 2024; Blair & Mataraarachchi, 2021; Zandieh et al., 2024). Although conventional linear systems lead to the environmental impacts shown in Figure 1, a zero-waste strategy systematically redirects organic and recyclable materials. Proper sorting, the recycling of materials, the use of anaerobic digestion, composting, and advanced bioprocessing (for example, to produce biopolymers, platform chemicals, and alternative proteins) enable these combined methods to greatly reduce the potential for methane emissions from landfills and result in a lower overall carbon footprint (Ijimdiya et al., 2026; Rahman et al., 2021; Yesil et al., 2025).

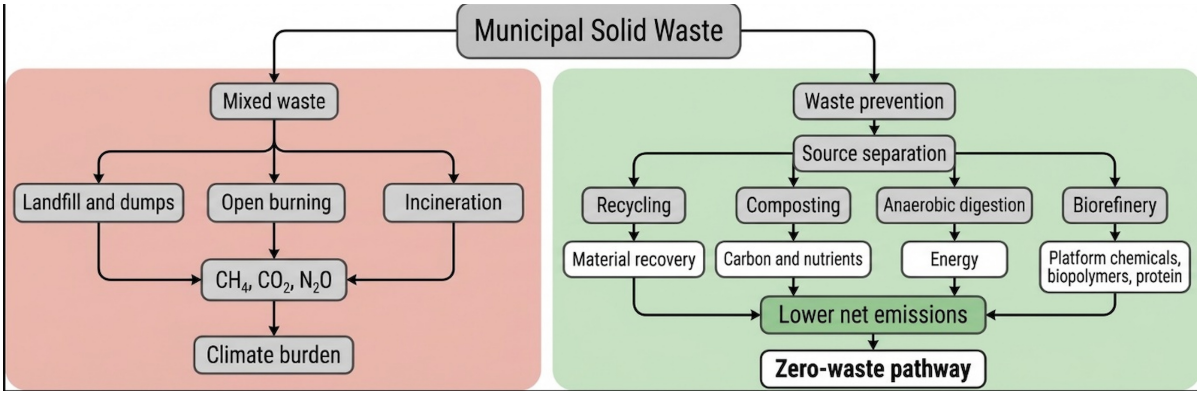

Figure 1. Linear versus circular municipal waste management pathways.

2. Paradigm Shift in Waste Management: Zero-waste framework

Within a zero-waste framework, waste prevention is the first priority because avoiding the waste creation delivers the greatest climate and resource benefits (Eléonore Maitre-Ekern & Dalhammar, 2019; Hou & Sarigollu, 2021). Consumer behavior is essential to this approach, as the success of the

circular economy relies on how products are obtained, used, maintained, and disposed of (Shevchenko et al., 2023). Redistribution of still-functional products through resale, donation, or passing along extends product lifetimes and directly prevents premature disposal (Hou & Sarigollu, 2021; Sarigöllü et al., 2020). Such actions are more influenced by people's attitudes toward waste minimization and their perception of a product's value, quality, and price than by their general concern for the environment (Hou & Sarigollu, 2021; Sarigöllü et al., 2020). The same logic applies to food systems, as global food waste continues to rise despite reduction efforts, leading to major carbon and resource impacts. Agri-food waste is one of the most common types of biomass worldwide, but traditional disposal methods such as landfilling or incineration result in serious environmental and economic losses (Pandey et al., 2025).

Where prevention is not feasible, evidence supports a recovery hierarchy that diverts food and biodegradable wastes from landfills and directs them to feed production, material recovery, or controlled biological treatment (Pandey et al., 2025; Tamasiga et al., 2022). Global data indicate that recycling food waste through composting, anaerobic digestion, or use as animal feed (i.e., protein) reduces emissions by about 1 tCO_2-eq per tonne compared with landfilling (Wang et al., 2025). The potential scale is large: avoiding landfill disposal of food waste could offset about 10%, 5%, and 17% of agricultural-system emissions in the United States, European Union, and China, respectively (Wang et al., 2025).

Composting is an important way to divert waste from landfills, but its environmental benefits depend on certain conditions (Nordahl et al., 2023). Data from a commercial scale indicate that composting food waste results in emissions that are 38 to 84% lower than landfilling, although methane emissions go up when low redox potential and low watering are provided, meaning that better turning and more careful control of moisture are needed in order to reduce emissions (Perez et al., 2023). Emissions of both methane and nitrous oxide vary greatly with aeration, turning frequency, moisture content, pH, the carbon-to-nitrogen ratio, and the overall process setup (Li et al., 2022; Liu et al., 2023; Nordahl et al., 2023). In nitrogen-rich wastes, nitrous oxide can become the main cause of warming, while in other systems methane is a major contributor (Liu et al., 2023; Nordahl et al., 2023). Anaerobic digestion generally offers a more effective and manageable circular solution since it processes waste and produces biogas, has fertilizer value in the form of digestate, and leads to measurable reductions in regional emissions (Jung et al., 2026; Tamasiga et al., 2022).

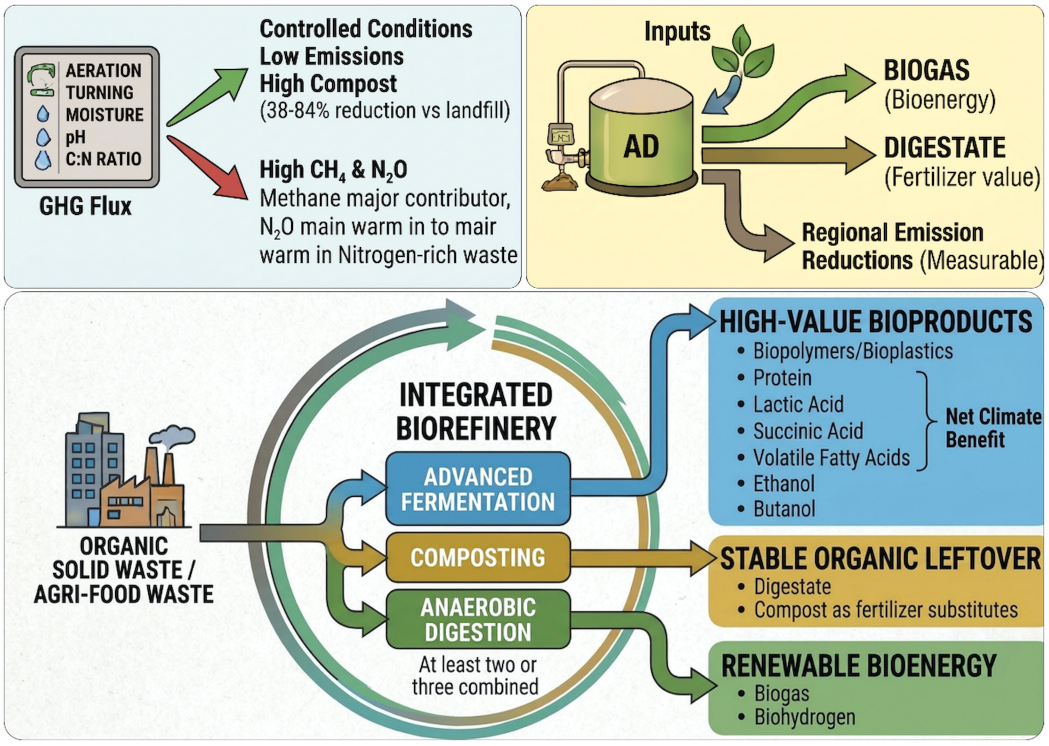

Figure 2. Multi-product valorization pathways for organic wastes with zero-waste framework

The biorefinery method goes beyond conventional waste recovery by using organic waste not only as a source of bioenergy but also as a source of higher-value bioproducts, rather than treating it as waste (Artola et al., 2024; Khoshnevisan et al., 2020). Reviews of urban biowaste and organic solid waste have shown possible routes for producing protein, biopolymers/bioplastics, lactic acid, succinic acid, biohydrogen, volatile fatty acids, ethanol, butanol, and other platform chemicals (Khoshnevisan et al., 2020; Yesil et al., 2025; Zhang et al., 2023). Life-cycle assessments show that biorefinery scenarios that involve municipal biowaste are generally environmentally friendly, since the processes for producing microbial protein, lactic acid, and succinic acid each offer net climate benefits (Khoshnevisan et al., 2020). As a whole, future waste biorefineries are expected to combine at least two of the biotechnological routes (anaerobic digestion, composting, and/or advanced fermentation technologies) rather than being designed as a single process to get benefit in terms of renewable energy, stable organic leftover, and a wide spectrum of bioproducts to be used as substitutes (Artola et al., 2024).

3. GHG Mitigation Through Carbon Recovery

Carbon recovery in the waste sector should be seen as part of a wider biorefinery approach rather than merely CO_2 capture, since biodegradable waste can be turned from a disposal problem into a source of carbon feedstock for producing fuels, chemicals, materials, and proteins (Li et al., 2026; Zheng et al., 2024). In various life cycle assessment (LCA) (Table 1), landfilling is the option that results in the highest emissions from organic waste, whereas redirecting the waste to controlled biological treatment and valorization greatly reduces its climate impact (Li et al., 2026). With regard to hydrogen production, one cradle-to-gate study found that dark fermentation followed by anaerobic digestion emitted 2.48 kg CO_2-eq per kg of H_2 and avoided 76.6 kg CO_2-eq compared to single-stage anaerobic digestion when processing 16 tonnes of food waste, while another biorefinery for hydrogen from food

waste reported an emission rate of 10.1 kg CO_2-eq per kg of H_2 and identified gas compression and electricity as the main environmental hotspots (Lee et al., 2024; Zheng et al., 2024).

Table 1. Representative LCA-based GHG values for waste-management and carbon-recovery pathways

Management / Pathway	Reported GHG Value	Main Hotspot	Study
Landfilling	~400 kg CO_2-eq/t	Highest-emitting benchmark in comparative LCA	Konti et al. (2020)
Composting	Often lower than landfill; values vary widely	Strongly affected by CH_4, N_2O, moisture, and aeration	Konti et al. (2020)
Anaerobic digestion	76.6 kg CO_2-eq avoided (for 16 t food waste)	Electricity use is a key driver	Lee et al. (2024)
Anaerobic fermentation for H_2	2.48 kg CO_2-eq/kg H_2	Excludes avoided heat and power in headline value	Lee et al. (2024)
Anaerobic fermentation for H_2	10.1 kg CO_2-eq/kg H_2	Gas compression, electricity, and transport dominate	Zheng et al. (2024)
Lactic acid production	1.38–0.44 kg CO_2-eq	Fermentation stage is a major contributor	Senila et al. (2024)
Acetic acid / VFA production	−0.4 kg CO_2-eq/kg VFA	Benefit driven by landfill diversion and avoided methane	Li et al. (2026)
PLA bioplastic	0.95–2.25 kg CO_2-eq/kg PLA	Feedstock and conversion route matter	Senila et al. (2024)
PLA bioplastic	1.9–4.3 kg CO_2-eq/kg PLA	Strong dependence on biorefinery fuel and end-of-life	Li et al. (2026)
PHA bioplastic	1.88 t CO_2-eq/t PHA	Methane leakage and electricity are critical hotspots	Martin-Gamboa et al. (2023)
PHA bioplastic	1–6 t CO_2-eq/t PHA	Literature range is broad	Martin-Gamboa et al. (2023)
Microbial protein	−58 to −147 kg CO_2-eq/t biopulp	Depends on integrated biorefinery configuration	Konti et al. (2020)

The greatest reductions in emissions are usually seen when waste carbon is turned into higher-value products rather than being recovered only as energy (Li et al., 2026). LCA studies have found negative or low net emissions for a number of fermentation-based products: food-waste VFA production achieved a figure of −0.4 kg CO_2-eq per kg VFA (Li et al., 2026), whereas the microbial-protein pathways in municipal biowaste biorefineries produced values between −58 and −147 kg CO_2-eq per tonne of biopulp (Konti et al., 2020). The situation is more varied with respect to lactic acid and bioplastic pathways: in one PLA production chain, lactic acid production can result in emissions of 1.38 to 0.44 kg CO_2-eq, while the PLA footprint varies from 0.95 to 4.3 kg CO_2-eq per kg of PLA according to the feedstock, energy source, and end-of-life assumptions (Senila et al., 2024). PHA production also shows a wide range, with a case footprint of 1.88 t CO_2-eq per tonne of PHA and a literature footprint of 1 to 6 t CO_2-eq per tonne, but methane loss control can reduce the footprint by more than 100% compared to that base case (Martin-Gamboa et al., 2023). In general, the evidence supports the argument put forward in recent reviews, such as that of Yesil et al. (2025), that shifting away from landfill and instead carrying out the integrated recovery of carbon into fuels, chemicals, materials, and proteins represents a plausible climate mitigation strategy, even though the outcomes are still very sensitive to energy inputs, leakage control, and process design (Konti et al., 2020; Li et al., 2026).

4. Halal Concept and Social Acceptance of Waste-Derived Products

Public willingness to engage in the separate collection and use of upcycled bio-products is strongly influenced by community education, safety perceptions, and local cultural values (De Boni et al., 2022; Di Fiore et al., 2022; Susanty et al., 2025). In Muslim-majority areas, incorporating the religious principle of halalan thayyiban, which requires that materials be lawful, hygienically pure, wholesome, and ethically produced, is a key factor in gaining social legitimacy (Arifin et al., 2021; Mujib & Salleh, 2026).

Extending the concept of halal beyond its rules regarding the slaughter of animals to include the whole supply chain links environmental responsibility with religious duty (Anisah, 2024; Aqila et al., 2026; Mujib & Salleh, 2026). For example, institutional canteens which introduce organized organic waste separation connect their day-to-day activities with rahmatan lil alamin (mercy to creation) and at the same time enhance consumer involvement (Aqila et al., 2026; Oemar et al., 2023). In a similar way, combining zero-waste practices with halal tourism in Lombok shows that environmental cleanliness is accepted by society as a concrete manifestation of Islamic faith (Rojabi et al., 2020).

The same applies to products that are derived from organic waste streams. It is technically possible to transform food waste and animal by-products into animal feed or pet food, but public acceptance depends on the establishment of strict Halal Assurance Systems (HAS) which confirm that there is no contamination with non-halal impurities (Mamdouh Al-Bataineh et al., 2025). The use of transparent digital traceability systems together with Islamic quality standards such as MS 1900 helps to build consumer confidence and promotes acceptance of the product (Arifin et al., 2021; Susanty et al., 2025; Tseng et al., 2022). By linking the technological processes for conversion to these cultural and religious ethical principles, resistance to circular waste products is greatly reduced (Anisah, 2024; Mujib & Salleh, 2026; Sulaiman, 2026). In general, sustainable biowaste circularity can only be achieved by combining life-cycle sustainability objectives with clear national policies and ethical frameworks such as halalan thayyiban in order to secure community trust.

5. Conclusions and Future Perspectives

Removing organic waste from landfills and redirecting it into the circular bioeconomy is essential. Although composting and anaerobic digestion immediately reduce emissions, biorefineries deliver the greatest climate benefits by transforming biowaste into renewable energy, soil conditioners, bioplastics, and proteins. However, prior to validation of the net-zero performance and market viability, it is necessary to carry out standardized life-cycle assessments and techno-economic analyses. Lastly, only by coordinating technical policy with cultural frameworks and digital traceability can seamless societal integration and sustainable governance be achieved.

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(I-03) RETHINKING WASTE MANAGEMENT: GLOBAL CHALLENGES AND LESSONS FROM JAPAN'S EXPERIENCE

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Abstract

This paper examines the transformation of waste management through Japanese policies, technologies and local practices, and considers the cultural and ethical foundations of zero waste in the context of the World Halal Summit. It argues that zero waste cannot be achieved solely through improved collection, recycling and disposal of waste after it has been generated. Sustained progress requires changes in the production and consumption behaviours that generate waste, supported by the coordinated consideration of technology, economics, governance, culture and ethics.

The focus of waste management is shifting from managing waste after generation to preventing its formation. The circular economy seeks to retain resources within the economic system through product design, extended service life, repair, reuse, remanufacturing and recycling. Zero waste should therefore not be equated with the recycling of all waste; prevention and reduction must be implemented as the highest priorities within the waste hierarchy.

Keywords: Sustainable Waste Management; Japanese Experience; Circular Economy; Eco-Town Initiatives; Kokoro and Environmental Ethics.

Strengths and limitations of the Japanese experience

Since the 1970s, Japan’s approach has evolved from pollution control and safe disposal towards the 3Rs, a sound material-cycle society and, more recently, the circular economy, carbon neutrality and resource security. The Fifth Fundamental Plan, adopted in August 2024, positions the circular economy as a national strategy requiring a whole-of-government approach. Strengthening links between manufacturing and resource recovery sectors, preserving resource value throughout the life cycle and advancing producer responsibility are central elements of this framework.

According to the fiscal year 2024 indicators presented in the paper, Japan generated approximately 38.11 million tonnes of municipal waste, equivalent to 839 grams per person per day, with a recycling rate of 19.3%. Approximately 991 municipal waste incineration facilities were operating as of March 2025. The relatively low quantity requiring final disposal is associated particularly with extensive thermal treatment capacity. Although incineration and energy recovery reduce landfill requirements, they do not constitute the ultimate objective of zero waste. The principal lesson is to conserve resources before they become waste and retain them in material cycles that preserve their value.

Kamikatsu and community participation in zero waste

Kamikatsu, which adopted a Zero Waste Declaration in 2003, illustrates a model based on coordinated behavioural change involving local government and the community. A recovery rate exceeding 80%

has been reported. Opened in 2020, the Zero Waste Center serves not only as a waste reception facility but also as a venue for learning, reuse and public participation. The value of its detailed separation system lies less in the number of categories than in residents' understanding of where materials go and why separation matters.

"The Kurukuru" reuse shop, refill initiatives, reusable tableware, packaging reduction and collaboration with producers integrate waste management with everyday consumption choices. Kamikatsu demonstrates that separation is a means of advancing reuse, resource awareness and waste prevention, rather than an end in itself.

Food waste prevention and mottECO

Food loss and waste constitute one of the clearest connections between zero waste and the halal economy. The paper reports that approximately 4.61 million tonnes of edible food were lost or discarded in Japan during fiscal year 2024. Food banks, donation campaigns, local food loss prevention programmes, separate collection, composting and anaerobic digestion are applied in combination. Priority is assigned to preventing edible food from becoming waste and redistributing it to people in need; resource recovery follows these interventions.

The mottECO initiative, which encourages restaurant customers to take uneaten food home under appropriate hygiene and responsibility guidelines, demonstrates that effective interventions do not invariably require advanced technology. It addresses business procedures, consumer habits, social perceptions and food safety together. Responsible consumption encompasses avoiding excessive purchasing, serving and disposal of uneaten food, alongside ensuring appropriate production practices.

Mottainai and kokoro in relation to Islamic ethical concepts

Mottainai expresses regret when the value of an object, food item or natural resource is lost before being fully realised. Valuing possessions, extending their use and incorporating reuse into daily life are practical expressions of this concept. Kokoro encompasses conscience, moral awareness, sensitivity and an internal sense of responsibility. Drawing on the author's experience in Japan, the discussion of technology, economics and kokoro emphasises that technical solutions and economic instruments require an accompanying commitment to moderation in consumption.

Within this framework, technology addresses cleaner production and resource recovery; economics examines how the true costs of resource use can be reflected in decisions; and ethics asks what level of consumption is sufficient. The paper identifies conceptual connections with the Islamic principles of avoiding israf, or wasteful excess; practising kanaat, or contentment; and recognising emanet, or entrusted responsibility. Viewing resources as carrying obligations beyond individual use provides an intrinsic motivation for waste prevention that extends beyond regulation and financial incentives.

Policy implications for Türkiye and the halal economy

The paper recommends adopting the underlying principles of prevention, evidence, education, producer participation and culturally informed communication, rather than merely transferring Japanese facility designs or separation systems. Priorities for Türkiye and the Islamic world include extending product life, supporting repair and reuse, strengthening producer responsibility for packaging and products after use, reducing food waste through measurable targets, and reinforcing

collaboration among local authorities, businesses, academia and citizens.

Discussion within the halal economy should extend beyond product composition and conformity of production processes to encompass overproduction, unnecessary packaging, water and energy consumption, and food waste. The relationship between halal, tayyib and zero waste is presented primarily as an area for strengthening responsible consumption and resource ethics, rather than as a proposal for a new certification requirement. Suggested measures include food waste prevention targets at events, refill and reuse systems, community education and practical behavioural programmes connected to cultural values.

Performance should be assessed through the quantity of waste prevented as well as the quantity recycled. The paper concludes that advanced technology must be developed and implemented in conjunction with moderation in consumption and shared social responsibility. Sustained progress towards zero waste depends on changes in production and consumption decisions that preserve the value of resources.

Brief implications for halal certification

As a possible future extension of these recommendations, halal certification schemes could consider proportionate supplementary criteria for waste prevention, safe food surplus redistribution, packaging reduction, and efficient water and energy use. An improvement plan, a few measurable indicators and periodic verification could translate the principles of avoiding israf and recognising emanet into practice. Such criteria should be developed through consultation and piloting, while preserving established Shariah, food safety and traceability requirements.

(I-04) WASTE MANAGEMENT IN TÜRKIYE AND THE ZERO WASTE APPROACH

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Abstract

Global municipal solid waste (MSW) generation is projected to increase from 2.56 billion tonnes in 2022 to 3.86 billion tonnes by 2050. In addition, approximately 1.3 billion tonnes of food are lost or wasted annually, posing a major global challenge with significant environmental, social, and economic consequences. Given that the waste sector accounts for roughly 20% of global anthropogenic methane emissions, primarily due to the decomposition of organic waste in dumpsites and landfills, addressing waste generation and management through sustainable approaches, including those integrated into the halal value chain, has become increasingly important.

This study provides an overview of MSW management in Türkiye in the context of global practices. It also examines the zero-waste approach and explores practices that could be implemented throughout the halal value chain. MSW generation in Türkiye increased from approximately 28.0 million tonnes in 2014 to 32.3 million tonnes in 2024. Meanwhile, the national waste recovery rate rose from 27% in 2021 to 36.1% in 2024 and 37.5% in 2025, with a target of reaching 60% by 2035. To achieve this target, Türkiye has strengthened its institutional and technical infrastructure in recent years while advancing its policy framework for waste management.

In conclusion, integrating zero-waste principles into the halal value chain, with a particular focus on environmental performance and resource efficiency, could help reduce waste generation, support the transition to a circular economy, mitigate environmental impacts, and promote sustainable consumption practices.

Keywords: Waste Management; Zero Waste; Circular Economy; Halal Value Chain; Sustainable Consumption

(I-05) A CROSS-SECTOR TECHNICAL INFRASTRUCTURE FOR HALAL-CRITICAL INGREDIENT ASSESSMENT IN OIC COUNTRIES

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Abstract

Halal assessment is becoming more complex as the origin of ingredients, processing conditions, and supply chain practices increasingly need to be considered alongside chemical composition and product testing. The Standards and Metrology Institute for Islamic Countries provides a common reference for Halal requirements, but the technical information generated when ingredients are assessed is often retained within individual assessment processes. As a result, information that may be useful for assessing the same or similar ingredients in other products, sectors, or countries is not always readily accessible.

This paper proposes a cross-sector technical infrastructure within the Organisation of Islamic Cooperation and the Standards and Metrology Institute for Islamic Countries context for organizing and maintaining such information. The proposed framework includes a Halal-Critical Ingredient List, Halal Ingredient Technical Dossiers, an Evidence-to-Attribute Assessment Matrix, Halal Ingredient Technical Monographs, and a Digital Halal Ingredient Passport. These components are supported by an Evidence Gap Register, change-control procedures, and an expert mechanism for technical review and updating. Rather than introducing another certification scheme, the framework is intended to provide a shared technical resource for competent authorities and other relevant bodies. National Halal certification and regulatory decisions would remain under the responsibility of the competent national systems.

By linking technical attributes with their supporting evidence and maintaining this information in a structured knowledge base, the proposed infrastructure could reduce unnecessary repetition in technical assessment and improve consistency and traceability. It could also make previously established technical knowledge available when comparable ingredients or assessment questions arise. The proposed approach therefore offers a basis for technical cooperation among Organisation of Islamic Cooperation member states while keeping shared technical knowledge separate from national conformity decisions

Keywords: Halal assessment; Technical infrastructure; Halal-critical ingredients; Digital Halal Ingredient Passport; Halal ingredient monographs

(I-06) SMART HALAL PACKAGING: ENHANCING FOOD SAFETY, TRACEABILITY AND CONSUMER TRUST

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Abstract

In order to ensure verified halal integrity, food safety, supply-chain transparency, and consumer confidence, the worldwide halal food business needs packaging technologies that go beyond traditional product protection. Opportunities to link halal certification with real-time food quality monitoring are provided by smart packaging technologies such as QR-code-enabled traceability, radio-frequency identification (RFID), freshness indications, time-temperature indicators, and intelligent sensors. The potential of smart halal packaging to support Pakistan's halal food sector, especially in meat, dairy, and other perishable food items were examined. According to this statistical survey research, meta-analysis of 15 food traceability, consumers' willingness to pay for traceable products reached a price premium of roughly 32% in the studies examined, with higher premiums for traceable meat and when traceability was coupled with characteristics like animal welfare. In addition, a survey conducted for 250 consumers in four major Pakistan cities revealed that safety-focused communication, nutritional enhancement and innovative packaging for better safety and consumer trust of food products with respect to intention of purchase. The emphasize on smart packaging's potential for real-time food-quality monitoring, enhanced safety and less food waste, while also pointing out the obstacles to commercialization. Building on these findings, the contribution proposes an integrated Smart Halal Packaging Framework that connects halal certification records, product origin, slaughterhouse or processing-facility information, batch identification, cold-chain history and digital verification accessible to consumers up to 60%. For perishable products, freshness and temperature indicators could supply additional quality information, provided they are validated against established microbiological and physicochemical criteria. The framework focused on tamper evidence, clear halal-certification information, food-contact-material compliance, data reliability and protection against fraudulent labeling. The projects focused on halal meat processing, dairy industries, packaging, halal certification and regulatory authorities to improve traceability for ease in recalls, credibility and consumers' purchasing aspects. The verification still depends on certification credibility, validated tests and regulations for halal authenticity and safe food for digital and smart packaging. This approach proved a more realistic pathway by combining packaging innovations with respect to halal assurance and consumer rights protection for sustainable economic growth.

Keywords: Smart halal packaging, Food safety, Traceability, Halal integrity, Consumer trust

(I-07) SUSTAINABLE HALAL FOOD PRODUCTION SYSTEMS: INNOVATIONS FOR SAFE, GREEN AND ETHICAL FOOD MANUFACTURING

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Abstract

Sustainable halal food production requires a holistic approach that unites halal integrity, Tayyib principles, food safety, resource efficiency, environmental responsibility and ethical manufacturing. With the global halal economy expanding, food manufacturers must move away from compliance-driven production toward systems that cut waste, conserve water and energy, enhance by-product utilization and maintain consumer trust throughout the supply chain. The emerging innovations and policy opportunities to advance safe, green, and ethical halal food manufacturing, with particular relevance to Pakistan's meat, dairy, and agro-food industries, were examined. The United Nations Environment Programme's Food Waste Index Report of 2024 estimated that more than 1.05 billion tons of food were wasted worldwide in 2022, roughly 19% of food available to consumers at retail, food-service, and household levels. In addition, the Food and Agriculture Organization estimated that around 13 to 15% of food is lost between post-harvest and retail stages. UNEP also linked food loss and waste to 8 to 10% of global greenhouse-gas emissions, underscoring the environmental and economic importance of resource-efficient production. The intervention evidence related to Pakistan emphasized the assessment of milk value chain in a report by Nestlé Pakistan that food losses and wastage of food are 1.4% across evaluation stages, most of which occur during collection, processing and distribution channel during milk supply chain. Our study focused on improving supply chain and enhancing ethical and green food manufacturing processes. Based on such findings, a Sustainable Halal Food Production Framework was developed which integrated halal assurance, hygienic food processing, green production, smart traceability, responsible and intelligent packaging and utilization of food processing in circular form and conversion to biodegradable by-products. The suitable dairy and meat-processing residues were recovered as value addition thus converting organic waste into compost and biogas to reduce wastewater pollution and enhanced cold-chain performance to 40% and 54% environmental and food-safety indications. The halal requirements were considered while conversion in biodegradable products with food-safety and environmental concerns. The sustainable halal manufacturing was assessed through measurable indicators, including product rejection rates, food loss per ton processed, water and energy consumption per unit of production, greenhouse-gas emissions, wastewater quality, by-product recovery and compliance with halal and food-safety standards. For Pakistan, coordinated action among regulatory authorities, certification bodies, universities, farmers and food industries could strengthen export competitiveness, lower production costs and support progress toward the Sustainable Development Goals (SDGs 2, 6, 7, 9, 12 and 13). The proposed framework positioned halal food production as a driver of ethical manufacturing, environmental stewardship and inclusive economic growth.

Keywords: Sustainable halal food production, Halal assurance, Green manufacturing, Food safety, Circular economy, Waste valorization

(I-08) THE NEXUS BETWEEN THE HALAL FOOD ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT OF OCCUPATIONAL COMPETENCIES OF TOP INDUSTRY MANAGERS

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Abstract

To maintain Halal food compliance, processing facilities must ensure rigorous Halal manufacturing protocols, whereas all secured by the top managers. Additionally, to build a long-term consumer trust, top managers should utilize a transparent Halal traceability system to prevent fraud, optimize resource of raw material, and minimize impact of misconducts.

Top industry managers usually face functioning difficulties to ensure Halal food processing, the events include logo misuse, lack of seriousness in applying regulations of Halal production. Unfortunately, many top food managers have misconception about the Halal food rules, as they see consider the rules as traditions that can be modified with any human-made food regulations

Top managers need to be trained about industrial executive function, digital traceability technology, total halal quality management, transparency in Halal food resources, increased customers` loyalty, Halal food traceability, Halal food mastery and commitment towards Halal food standards.

The top managers and workforce within the operation units should stay updated with Halal food industry regulations and standards to ensure compliance and maintain consistent production system for a better Halal end-product in terms of quality, safety and culture appropriateness. Therefore, this article explores the key skills and competencies that the lead top managers to be improved about including Halal food manufacturing protocols.

It is urgently for Muslim legislative bodies (e.g. SMIIC) to begin implementing certain procedures and development programs regarding the Halal food regulations and specifications for production facilities and their personnel, including top managers.

Keywords: Halal industry, food top managers, Halal industry occupational competencies Halal economy growth, Halal supply chain.

(I-09) FERMENTATION-BASED DEVELOPMENT OF HALAL MEAT ANALOGUES: PROCESS, PROTEIN FUNCTIONALITY AND SENSORY PERCEPTION

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Abstract

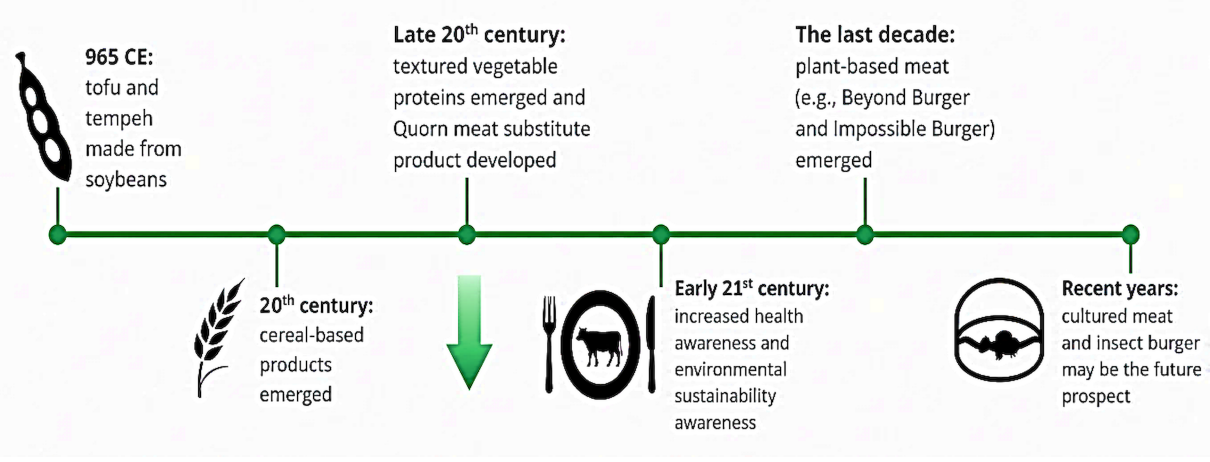
Global halal food market is growing fast with demand for nutritious and sustainable alternates. The consumption of plant-based foods and meat Analogues is increasing due to consumer awareness about their health and ecological impacts. Meat Analogues are considered halal alternative to meat consumption, however, they have certain drawbacks such as low nutritional value; since vegetable proteins are considered nutritionally inadequate due to deficiencies in essential amino acids or the presence of anti-nutrients. The fermentation process is accredited as an alternative process that can improve nutritional attributes and sensory perception. A study on fermentation process optimization using Rhodotorula mucilaginosa and Monascus purpureus to produce meat Analogues from soy protein was conducted. Regarding the nutritional characteristics, the content of amino acids, proteins, fiber, saturated fat, vitamins, anti-nutrients, and phenols were evaluated. The results showed a significant improvement in the content of amino acids, vitamins, and phenols, unlike the fiber content, whose results were non-significant. The saturated fat as well as the anti-nutrient content produced by the phytase activity were reduced. In sensory studies, characteristics like texture, color, flavor, and overall acceptance were assessed. The results showed that the fermentation process produced a decreasing trend in hardness and chewiness, an increase in elasticity and cohesion, and a decrease in luminosity and yellow tones, thereby increasing the redness of the samples. There was an improvement in overall flavor by decreasing beany flavor. Hence, it was concluded that the fermented meat Analogues are considerable halal alternative to traditional meat products and the fermentative process substantially improved the nutritional and sensory attributes of meat Analogues.

Keywords: Halal meat alternatives, process optimization, fermentation, nutritional properties, sensory perception.

Introduction

The main source of the highest quality protein is meat due to its nutritional and sensory characteristics, which contain a large amount of essential amino acids (1). The increase in the population has produced an increase in meat consumption worldwide, forecasting that the consumption of meat products will double by the year 2050 (2). Despite this, the consumption of animal meat involves several challenges related to environmental sustainability, human health, ethical reasons (3), and religious beliefs (1). The Spanish Agency for Food Safety and Nutrition (AESAN) recommends the

consumption of meat in a moderate and limited way, since excess is associated with different pathologies such as cholesterol, obesity, or even different types of cancer (4). Given these factors and the need to guarantee a healthy life and promote well-being, the need to promote a plant-based diet arises, as it presents multiple benefits associated with disease prevention, as well as high amounts of vitamins and minerals (5). For this, there is a strong demand for vegetarian or vegan foods that occupy an increasingly larger space in the market (1), being able to find the so-called meat analogs, imitation meat, or meat substitutes. Meat analogs are those products that have structural and sensory characteristics similar to those of meat, generally texture, flavor, and appearance (1,3). These can be classified into textured vegetables (soy, peas, gluten, etc.), cellular (*in vitro* or cultured meat), and microbial (mycoproteins, single-cell protein, SCP). However, the main ingredient used for these products is protein (textured vegetable protein, TVP), especially soybean and gluten due to their ability to reproduce certain characteristics of texture, appearance, functionality, and nutritional value of meat (6,7).



TVP is considered one of the first meat analogs launched, obtained from defatted soybean meal, soy protein, or wheat gluten (8), and its usefulness can be divided into three types of products: ground, shredded, and whole muscle. Currently, we can find a large number of similar meat products such as hamburgers, nuggets, sausages, steak, etc., some of them being made based on centuries-old recipes that include wheat, gluten, rice, mushrooms, legumes, tempeh, or pressed tofu (1).

Figure 1. History of meat analogs (8).

Various ingredients are used to achieve nutritional and sensory characteristics similar to those of meat. Among them is soybean, which is rich in carbohydrates, fats, fibers, macro- and micro-nutrients, and vitamins, able to mimic meat fibers, increasing fibrous toughness and chewiness. Cereals, such as wheat, barley, rice, and oats, especially wheat gluten due to its viscoelastic capacity, and legumes, such as peas, lentils, lupins, chickpeas, and beans, for their essential amino acids. However, they have low levels of methionine and are difficult to digest. Lipids or fats that act as binders, providing juiciness, tenderness, and a particular flavor; and algae, including macro and microalgae, which are great sources of protein. The manufacturing process of meat analogs consists of extrusion cooking, which is a technique carried out using high temperature, precision, and shearing, producing molecular fusion, mixing, and structural formation of proteins, thus transforming food into a paste. capable of being molded with a certain texture after expansion (7,9). The process can be conducted with low or

high humidity. In the case of low-moisture (LME, Low-moisture Extrusion) or dry extrusion, the products are the resulting products do not have a defined fiber content and need hydration before consumption, presenting a long useful life. In contrast, high moisture extraction (HME) results in fresh, premium meat analogues with a defined fibrous structure, presenting an enhanced visual appearance and flavor sensation. This occurs because cooling during extrusion is capable of avoiding the expansion of the product; however, the useful life is shorter (7,9). Despite this, the nutritional quality of proteins depends on several factors such as bioavailability, digestibility, amino acids, antinutrients, and other factors, one of the major problems being the presence of antinutrients such as phytic acid, lectins, saponins, and enzyme inhibitors, which are capable of affecting the bioavailability of minerals and the digestibility of proteins and carbohydrates (3). In addition, there are drawbacks such as the fact that these products may not resemble the sensory characteristics of meat, which may be a limiting factor for their acceptance, or that, in the case of using vegetable proteins, they may have a strong plant flavor due to lipoxygenases, saponins, and isoflavones.

As a consequence of the increase in demand for meat analogs, alternative methods that reduce the presence of antinutrients and optimize their flavor and functionality should be studied, helping to preserve the nutritional and sensory characteristics of meat (4). Fermentation consists of carrying out controlled microbial growth in the food, converting the components of the products by means of enzymes that break down the organic molecules into simpler ones. Currently, there is a high demand for these products, as some of them are related to beneficial health effects as a result of having a probiotic effect or containing bioactive peptides. Fermentation also causes the conversion of phenolic compounds into biologically active compounds, as well as a reduction in the presence of antinutrients and the appearance of improved flavors and aromas as a consequence of desirable biochemical changes responsible for the modification of food (11,12).

Among the advantages of fermented foods, we can find a longer shelf life, an improvement in sensory and organoleptic properties, the elimination of undesirable compounds, reduction in cooking time, and a greater antioxidant capacity. However, the factors that influence the fermentation process, the composition of substrates, and the microorganisms used in fermentation, among others, must be taken into account (12). In the case of meat analogs, since vegetable proteins are considered nutritionally inadequate because they are deficient in essential amino acids, this treatment is capable of enhancing the nutritional profile and providing a longer shelf life. (5,13). This fermentation can be produced by two techniques: solid-state fermentation (SSF) and submerged fermentation (SMF). SSF is produced in the absence of or with a very limited amount of water, while SMF is carried out with a high volume of water; it is important to establish that the fermentation results will depend on the proteins and microorganisms used (13).

Fermentation can be produced by bacteria or by fungi. In the case of fermentation produced by fungi, it is usually used as an alternative to the use of vegetable proteins due to their problems associated with antinutrients and allergenicity (14). These are rich in proteins and the use of certain SCPs that seem to be capable of providing a fibrous texture similar to that of meat. For this, filamentous fungi have been used, such as *Fusarium graminearum* (although it is characterized by its perception by consumers as a "pathogenic mold"), *Rhizopus oligosporum* (used for the production of tempeh for years) (15), *Agaricus bisporus* or *Pleurotus sapidus* (16). On the other hand, in the case of bacteria fermentation, it is being studied whether this treatment can be used to degrade phytic acid thanks to

the production of phytases, although this depends on the substrate and microorganisms (3) or the use of certain lactic acid bacteria (LAB) or of the *Bacillus* genus, such as *Bacillus subtilis*, to see if they are capable of improving texture or color of the meat substitute (17). Therefore, fermentation may be able to optimize nutritional values and organoleptic properties, and increase shelf life, inhibiting the growth of pathogenic microorganisms as a consequence of microbial metabolism. Microorganisms are capable of synthesizing enzymes that hydrolyze ingredients and provide good nutritional and organoleptic characteristics to the product, in addition to reducing antinutrients. From this arises the need to continue studying the use of this process in the food industry to obtain meat analogs that, in addition to being safe, present the protein content and quality of meat and thus be able to reduce the environmental impact that it generates, in line with the Sustainable Development Goals (SDGs) of the 2030 agenda. Meat alternatives could help to effect various changes related to some SDGs, such as "zero hunger" (SDG 2) or "health and well being" (SDG 3). Regarding hunger, it is known that it can be due to conflicts caused by humans, climate change, and the economy (19), so the use of these new products could help since they are capable of avoiding climate pollution or deforestation by reducing the environmental impact. produced by meat; In relation to health and well-being, meat products have been associated with chronic diseases, colorectal cancer, cardiovascular disease, etc. (20). So, meat substitutes could be a healthier alternative, promoting public health and social well-being.

This bibliographical review is carried out to evaluate the potential use of microbial fermentation to improve the sensory characteristics of meat analogs and nutritional values owing to complex metabolic pathways and proteolytic and lipolytic activities of microbial origin (18). The aim is to determine whether this process would be capable of producing safe foods with different physicochemical characteristics (taste, texture, and color), helping to remind one of traditional meat products.

Microorganisms, substrates and fermentation conditions in the synthesis of meat analogs.

Microorganisms

Fermentation in meat analogs can be carried out by molds, bacteria, and yeasts. The use of bacteria such as Bacillus subtilis (17) is frequent, although especially LAB (*Lactobacillus plantarum*, *Lactobacillus acidophilus*, *Lactobacillus delbrueckii*, *Bifidobacterium lactis* (3, 22, 23), while a large number of fungi have been used for the production of mycelia (*Rhizopus oligosporus* (24-27), *Agaricus spp.* (24), *Aspergillus oryzae* (28), *Agaricus bisporus* (29), *Fusarium venenatum* (30), *Pleurotus sapidus* (16), including yeasts such as *Kluyveromyces lactis*, *Kluyveromyces marxianus*, and *Torulaspora delbrueckii*) (31).

Substrates

There are various ingredients of plant origin used as substrates in the preparation of meat analogs, such as soybean and pea proteins, wheat gluten, and peanut proteins. The most widely used is soy protein since it has been found to have all essential amino acids, adequate nutritional characteristics, availability, and low costs. However, it has some disadvantages, such as the taste of grass and beans or bitterness (22). However, SCP based on filamentous fungus mycelia is being studied as it constitutes a strategy with great potential for the preparation of meat analogs. This is due to certain attributes such as the flavor of the meat provided by the presence of sulfur and glutamic acid, the presence of dietary

fiber, the texture similar to that of meat, and its chewiness (22). Furthermore, according to the research by Zhang *et al.* (32), the use of fungal mycelia is feasible for the process of preparing meat analogs, as they are easy to grow and harvest.

Fermentation Conditions

Fermentation is a process that has been commonly used to reduce pH and water activity to prevent pathogen growth. In recent years, studies have emerged in which this process seems to improve some nutritional and sensory characteristics (22).

Changes in the sensory attributes of meat analogs produced by fermentation

Sensory properties are those attributes that can be detected through the senses: color, flavor, aroma, and texture. The development of meat analogs presents several challenges, including technological ones, to imitate the texture, flavor, and general appearance of meat (6) and thus increase its consumption and promote good eating habits in the population.

Texture

Texture parameters can be divided into elasticity (the ability of the food to return to its initial size), cohesion (ability to excite internal bonds that make up the food), chewiness (easiness to chew the food), and hardness (force required to disintegrate the food). Maung *et al.* (17) carried out a study on TVP fermentation with *Bacillus subtilis* and different moisture contents (40% or 50%), in which they analyzed the texture parameters taking into account elasticity, cohesion, chewiness, and hardness, which were significantly affected by the established fermentation time. Fermentation modified the hardness and chewiness with a decreasing tendency as the fermentation time increased from 0 to 60 hours. Regarding elasticity and cohesion, they increased with fermentation time. Despite the results shown in this work, it is established that the moisture content used can affect the texture profile analysis (TPA), as it is concluded that the TVP with 50% moisture obtained greater chewiness and hardness than the TVP with 40% humidity. The results of this study coincide with those of Razavizadeh et al. (34), in which there is also a decrease in the hardness and chewiness of meat analogs made from okara fermentation carried out by *Lactobacillus plantarum* and *Lactobacillus acidophilus*. Improvement in texture occurred especially with the starter culture Lactobacillus plantarum, which produced greater acceptance in terms of texture of the fermented products with respect to the control samples.

Kaleda *et al.* (3) developed a study on the impact of fermentation on oat and pea proteins for the formation of meat analogs. Regarding TPA, it was concluded that the product resulting from fermentation was 40% harder and 25% more chewy; however, it was less cohesive. The authors state that further optimization is needed in the production of meat substitutes to make them more similar to meat products. Rousta *et al.* (28) carried out an investigation on the use of *Aspergillus oryzae* for the elaboration of fungal hamburgers and, to determine the texture, carried out a sensory evaluation. In the results, it can be seen that the texture could be too soft and smooth, while some participants commented that the texture was ideal.

Color

Color can be determined using the CIELab scale: L*: lightness, from black to white, a*: redness and b*: yellowness. Maung *et al.* (17) determined the color values in the control and fermented TVPs, concluding that fermentation time significantly affects lightness, redness, yellowness, and color difference; L* and b* decreased with fermentation time, while a* increased as fermentation time increased. These results coincide with those found by Kaleda *et al.* (3), who measured the color in samples of fermented oat and pea proteins and established significant differences, especially when there was a decrease in L*. However, this study determines that the color of meat analogues will depend on the manufacturing process, especially the temperature and humidity of extrusion. However, the results of previous studies do not coincide with the study carried out by Razavizadeh et al. (34), in which it is established that no significant differences attributed to color were found between fermented and nonfermented samples of meat analogues, although a slight tendency to a decrease in L* of the meat analogs could be observed in comparison with a traditional meat product.

Flavor

One of the drawbacks of meat analogs is the presence of off-flavors of grass or bean. In soybean proteins, the off-flavor of grass or beans is due to lipid oxidation, the presence of saponins, the presence of phytochemical and phenolic acids, as well as the presence of hexane, 2-4-decadienal, and 2- 4-nonadienal (10). To eliminate these undesirable flavors, techniques such as defatting, elimination of lipoxygenases, and even the fermentation process are used (35). In the study by Kaleda *et al.* (3), a sensory analysis was performed to study extruded unfermented samples and LAB-fermented samples. The results obtained were related to an improvement in the general flavor, although in some cases unpleasant attributes were obtained. These results coincide with those obtained by Razavizadeh *et al.* (34), where he was led to fermentation of okara was carried out by LAB (*L. plantarum* and *L. acidophilus*) to make meat analogues. The control samples were classified by the panelists as intense, bitter, and with an atypical flavor; on the contrary, the fermented samples, especially by the L. plantarum strain, were perceived as having some acidity, mild sweetness, fresh, and with a balanced flavor. These results of improvement in the flavor properties of fermented meat analogs are compiled in the review by Flores *et al.* (10). In this, it is stated that, thanks to fermentation, unpleasant flavors can be eliminated and the umami flavor can be enhanced in vegetable sausages through proteins of vegetable origin, due to the improvement of the solubility of the proteins and the increase in the amount of amino acids. Yousef *et al.* (31) investigated the use of LAB and yeast, *K. lactis*, *K. marxianus*, and *T. delbrueckii*, in a solution of pea protein to create meat alternatives. The results showed a significant reduction in grassy flavor and a higher overall aroma intensity in the presence of yeasts and LAB, although a slightly higher 'beer/yeast' aroma was obtained than in the control samples.

In the case of vegetable protein fermentation with filamentous fungi, Rousta *et al.* (28) carried out a study on submerged fermentation of *A. oryzae* using oatmeal as a substrate for vegetable burgers. The results showed that the vegetable burger had a slightly salty, bitter, and acidic taste, and it was established that the taste depends on the substrate, the chemical compounds generated, and the enzymes present. Despite this, some panelists highlighted the umami flavor of the mushroom burger. Therefore, mushroom-based plant products have a more pleasant flavor than those made from

soybeans or other legumes that have bitter tastes. The results of this study are related to the data obtained by Rathore *et al.* (29), made with mushrooms can be an innovative and promising application to enhance flavor. Therefore, the study by Clark *et al.* (36) established that the fermentation of vegetable proteins with the shiitake mushroom improved the taste and the general acceptance by consumers (36).

Global acceptance levels of fermentative meat analogues

The use of meat alternatives is increasing; however, it is important to take into account the levels of acceptance of meat analogues by the consumer, since these must be similar to traditional meat products not only nutritionally, but also in the sensory sense. In the study by Kaleda *et al.* (3), where the fermentation process was applied to pea proteins mixed with oats to prepare meat analogs, a sensory analysis of fermented samples and samples without ferment. The results showed a greater overall flavor intensity and better chewiness in the fermented samples; however, these presented sour, cereal, legume aromas and flavors and intense aftertastes. In the study by Razavizadeh *et al.* (34), ten panelists carried out an acceptability test. The appearance, smell, taste, and texture, as well as the general acceptability of meat analogues made by fermenting okara from LAB were evaluated.

The results showed a reduction in hardness, an increase in juiciness, and a significant acceptability of texture by consumers. The taste properties were described as intense and with a slight atypical flavor, producing a greater acceptability of the flavor of the fermented products than those of the controls. In the study by Rousta *et al.* (28), sensory analysis of hamburgers made with fermented oatmeal with A. oryzae was carried out. Most of the panelists showed that they neither like nor dislike the taste of the mushroom burger, while some participants showed that they liked the taste 'extremely.' Some attributes that were perceived in the taste of the vegan burger were that it could have a salty, bitter, acidic, or rancid taste, although some panelists showed that it showed a meat flavor. Regarding texture, half of the panelists did not like the texture of the burger; however, others indicated that it was fine for them, and the rest indicated that it was too smooth and that they wanted a harder texture. Yousef *et al.* (31) studied the fermentation of pea proteins by LAB and yeast, with the aim of producing plant-based products. In this study, fermentation improved sensory perception and decreased unpleasant vegetable flavors and odors. The overall aroma intensity in the presence of yeast was significantly higher than in the LAB culture. In the study by Hashempour-Baltork *et al.* (39), a comparison of products made from fermented mycoproteins and other traditional meat analogues such as tofu was carried out. The results showed that the liking of SCP was higher than that of other more traditional meat alternatives. In the case of the preparation of analogs with fungi, in the study by Stephan *et al.* (16), vegan sausages were made with mushroom mycelia from the mushroom. *P. sapidus*; the sensory analysis was carried out by 15 panelists and showed that this product is capable of offering characteristics similar to those of traditional meat-based sausages.

Nutritional changes in meat analogues produced by fermentation

Amino acids and proteins

Essential amino acids define the nutritional quality of protein. For the preparation of meat analogues, vegetable proteins are considered nutritionally incomplete since cereals are usually deficient in lysine and legumes are low in methionine and cysteine. In the study by Kaleda *et al.* (3), where fermentation

and phytase treatment are studied in a mixture of oat and pea proteins, the results show positive results, finding significant differences in the amino acid profile of the fermented samples compared to the control samples. In this study, fermentative treatment was able to double free amino acids compared to the control (1.77 ± 0.12 and 0.85 ± 0.08 mg g 1). Specifically, the content of Ala, Cys, His, Ile, Lys, Leu, Phe, Pro, Ser, Tyr, and Val increased, although the content of Arg, Asn, and Asp decreased. These results are confirmed by the study by Razavizadeh *et al.* (34), in which it is stated that the fermentative treatment of okara by means of LAB to produce meat analogues leads to the production of a large amount of essential amino acids. Regarding mycelia, the study by Rathore *et al.* (29) states that the fermented mushroom mycelium contains a high content of amino acids and proteins (between 20-30%), which is why it is a good source for the formulation of meat analogs. Regarding protein content, Rousta *et al.* (28) investigated oatmeal fermentation by the fungus *A. oryzae* for the preparation of meatless hamburgers. After 48 hours of fermentation, the protein content increased by 11%, which shows that the fermentative treatment would be effective in increasing the protein content and therefore the nutritional value of the meat analogs. Hashempour-Baltork *et al.* (39) stated that the consumption of SCP produced by fermentation contains a high protein content, so it can be beneficial to develop meat analogues, although the protein content is lower compared to traditional meat products. In the study by Lee *et al.* (26), where *Bacillus subtilus* fermentation was carried out on tofu, the peptide content increased from 6.5 to 18.3 mg/L after 12 hours of fermentation.

Fiber

The low fiber content of food is related to the appearance of certain diseases such as obesity, diabetes, and high blood pressure, so the presence of fiber is important in the preparation of meat substitutes. In the study by Nayak *et al.* (24), an experiment was carried out in relation to the fermented texture profile using *Rhizopus oligosporus* and *Agaricus fungus*, where it is concluded that this could be used as a good meat analog due to its sensory and nutritional results. In this article, the crude and dietary fiber content was determined, where it is confirmed that fermented foods contain a greater amount of fiber. Specifically, the crude fiber content was 2.58%, while the dietary fiber content was 12.54%. In the results of the study by Lucke *et al.* (25), where *Rhizopus* fermentation is studied on the rapeseed press cake to develop meat alternatives, the fiber content was increased, although minimally. In their conclusions, it can be seen that the fiber content before fermentation was 10.8%, while after fermentation the content was 11.9%.

Saturated fatty acids

The consumption of saturated fats in food increases the LDL cholesterol content, which contributes to the risk of heart disease and other prevalent diseases such as diabetes, high blood pressure, etc. In the study by Nayak *et al.* (24), it is shown that fermented foods such as soy protein for the preparation of meat analogues have a lower saturated fat content since the total fat was 8.54%, while the saturated fat was 0.54. %. Furthermore, it is established that the energy value of fermented vegetable products is 212.10 Kcal/100g, which corresponds to half the energy content of unfermented soybeans (24). Hashempour-Baltork et al. (39) investigated the consumption of fermented SCP to make meat substitutes, and their results showed that fats are mainly composed of polyunsaturated fatty acids (PUFA), linolenic acids, and linoleic acid. In a study by Polanowska *et al.* (27), fermentation carried out by three strains of Rhizopus oligosporus was investigated, demonstrating that this process is

capable of reducing the total content of fatty acids, results that coincide with those of Hashempour-Baltork *et al.* (39) and Nayak *et al.* (24).

Polyphenols

The presence of phenolic compounds contributes to increased antioxidant activity. Xing *et al.* (33) carried out a study to determine whether fermentation can produce changes in a chickpea protein concentrate prepared for meat alternatives. It was observed that after fermentation, all samples had an increase in total phenolic compounds (CPT). However, in the study by Polanowska *et al.* (27), where fermentation carried out by three strains of Rhizopus oligosporus was investigated, it can be observed that the phenolic content decreased at the beginning of fermentation; despite this, from day 20 of fermentation there was an increase in CPT, and free radicals were reduced. During the fermentation process, all strains produced an increase in quercetin and kaempferol; however, the apigenin and coumaric acid content was increased only by one of the strains. The content of catechin and p-hydroxybenzoic acid decreased in all strains. It is established that prolonged fermentation can be beneficial from the point of view of phenolic compounds, but such prolonged fermentation can create off-flavors and aromas.

Vitamins

According to the study by Rathore *et al.* (29), the use of fungal mycelia is considered a good source of bioactive compounds such as ergosterol, which is a precursor of vitamin D. There are SCPs with a high content of vitamins (*A. bisporus*, *Ganoderma lucidum*, *Lentinula edodes*). However, in the SCP study by Hashempour-Baltork *et al.* (39), it is stated that the B12 content is lower than in red meat.

Antinutrients

Plant products can contain antinutrients that interfere with protein and carbohydrate digestibility and mineral bioavailability. The most common are phytic acid, saponins, and lecithins (28).

Impact on consumer health and comparison with traditional meat products

SCPs are capable of producing a decrease in LDL and serum cholesterol and therefore in the risk of cardiovascular disease. The beneficial results of SCP consumption are consistent with Finnigan *et al.* (40), where it is confirmed that they contribute to a healthy diet and have beneficial characteristics such as promoting muscle synthesis, controlling glucose and insulin levels, and increasing satiety. In the study by Hashempour-Baltork *et al.* (39), SCP consumption was related to a reduction in total cholesterol and LDL cholesterol, an increase in HDL, as well as effects on satiety and glycemic responses. The results coincide with those of Thavamini *et al.* (30), where it is confirmed that the use of SCP produced by *Fusarium venenatum* can cause a reduction in cholesterol and is low in sodium. In a study by Sasikumar *et al.* (23), a protein isolate is fermented from the seeds of the blood fruit to develop vegetable alternatives. In this study, the presence of bioactive peptides in the resulting products was observed to have antimicrobial, anticancer (colorrectal cancer, tumors), antidiabetic properties, and the ability to reduce the prevalence of heart disease.

Comparison of meat analogues and traditional meat products

When the values of traditional meat are compared with those of SCP and TVP, an increase in

carbohydrates and fiber is observed with respect to traditional meat products. However, energy increases only in TVP and fat in SCP. However, although protein values increased in TVP and SCP, the value of traditional meat continues to contain a higher protein value (24,39).

Table 1. Nutrients in traditional meat, SCP, and TVP per 100g.

	Traditional meat	SCP	DVT
Energy (Kcal)	191.3	85	212.10
Total fat (G)	2.8	3.25	0.54
Proteins (G)	23.2	11.25	17.40
Carbohydrates (G)	0	3	16.59
Fiber (G)	0	6.25	12.54
References	(39)	(39)	(24)

Discussion and explanation

The preparation of meat analogues has been used for centuries. These analogues can be made using LME or HME (7,9). However, they have some drawbacks, such as the presence of antinutrients, amino acid deficiencies, or that they are not sensorially similar to meat, exhibiting off-bean or grass flavors. As a consequence, researchers consider the use of the fermentation process to improve nutritional and sensory attributes.

Sensory attributes

In relation to texture, hardness and chewiness decreased, contrary to elasticity and cohesion. The results are associated with DVT proteolysis as a consequence of neutral, alkaline, and esterase proteases. However, these results did not coincide in all the articles found, since the modifications of the texture parameters will depend on the size and type of the substrate, the microorganisms used, the humidity, and the fermentation conditions (3, 17, 28, 34). Therefore, given the results and the limited research, a greater number of studies are needed to investigate fermentation conditions, microorganisms, substrates, etc., capable of producing textural improvements. The color attributes showed a decrease in L* and an increase in a* (3, 17, 34). These results are associated with the fact that fermentation produces protein hydrolysis, producing Maillard reactions and affecting the color of the samples (17). However, one of the limitations of the review is that few studies have been found, and some of them do not coincide, requiring a greater number of experiments that answer the fermentation conditions to produce colors similar to meat. One of the biggest drawbacks of TVPs is their beany or grassy flavor. In the referenced investigations, there was an improvement in the general flavor, although not in all the studies found (3, 10, 28, 31, 34, 36). This improvement in flavor is produced by the increase in volatile compounds as a consequence of fermentative treatment. During the formation of flavor, a molecule capable of being transformed into an aromatic compound by means of proteins, carbohydrates, or lipids is generated. Therefore, flavor improvement can be related to amino acid degradation through the activation of exogenous peptidases and proteases, and thus generate alcohols, aldehydes, esters, and sulfur compounds (10). The increase in amino acids after fermentation increases the perception of sweet taste, as well as the oligopeptides contributing to the bitterness of the food, while the acids provide greater acidity and are responsible for off-flavors (3, 37).

Likewise, uncontrolled fermentation can also cause the appearance of strange flavors (27). Therefore, given the improvements in flavor, volatile compounds increased in all the studies found, especially ketones and aldehydes, so there is enough research capable of demonstrating the increase of these substances through fermentative treatment and, consequently, their relationship with perceived taste (3, 22, 36, 37, 38). The sensory parameters analyzed in the review seem to contribute to a higher acceptance of fermented meat analogues compared to nonfermented ones. However, given the small number of studies, more research is needed to answer some questions such as: What are the optimal fermentation conditions to improve the textural properties of the analogs? Does the choice of the substrate influence the hardness of the analogous material? Can different strains affect texture and color attributes differently? What are the optimal conditions of the fermentation process to reduce grassy or bean flavors?

Nutritional attributes

Fermentation improves the content of amino acids and peptides, coinciding with these results in all articles found and there being sufficient evidence of these benefits (3, 26, 28, 29, 34). This effect is due to proteolysis and the formation of peptides by hydrolysis of microbial enzymes as a consequence of fermentation (26). Similarly, saturated fats were reduced, reaching the main conclusion that the decrease can be associated with strains, but also because the fermentation process is capable of producing microbial enzymes, especially lipases, capable of degrading food fats (24, 27). During fermentative treatment, the strains release enzymes that digest macronutrients and affect the fiber and vitamin content (12). Despite this, a greater amount of research is needed to study the fermentation-fiber association and the increase in vitamins, because in relation to fiber, in some studies the content was increased (24), while in others no significant differences were established (25). While the vitamin content increases, although it is still lower than in traditional meat products (29, 39), giving rise to new research questions such as: can meat analogues, thanks to the fermentation process, ¿equal or exceed the vitamin content compared to meat products? The content of antinutrients, such as phytic acid, is another major drawback of TVPs, as they chelate minerals, reducing their absorption (36). The review shows that the fermentative process decreases the phytic acid content as a consequence of the phytase activity of the microorganisms used (33,36). Despite the associated benefits, the number of articles found establishes the need for a greater number of investigations that not only establish the benefits but also optimize the process (41).

Regarding the CPT content, there was an increase in the phenol content in the review, with evidence of the beneficial relationship between fermentation and the increase in CPT (26, 27, 33). These results can be explained by the microbial or enzymatic conversions produced during fermentation. One of the triggers for the increase in CPT is the release of β-glucosidases during fermentation, which are capable of releasing aglycones or quercetins (26, 40). The improvements produced during fermentation directly influence the health of consumers. In all the publications found, the consumption of fermented analogs caused improvements in parameters such as LDL, HDL, cholesterol, or tumor markers (23, 30, 39, 40). These results are associated with an improvement in the content of amino acids and minerals. This improvement in consumer health, as well as the greater acceptance of fermented meat analogs, can be considered a strength; On the contrary, one of the limitations of the review is that the fermentation conditions, as well as the strains used, are highly variable, requiring optimization of the fermentation process.

Following further research, the consumption of meat analogs could prove to be a good source of protein to replace meat and help meet certain SDGs. Traditional meat production produces higher emissions than plant-based products (20). Therefore, replacement of traditional meat products can help meet SDG 13 "Climate Action", since the carbon source is between four and ten times less than that of beef and chicken meat, playing a role in the reduction of challenges in food production systems and their effect on greenhouse gases (39). The improvements provided by meat analogs regarding nutritional attributes can be a trigger to meet SDG 3 "Health and well-being" as they are capable of reducing prevalent diseases such as cardiovascular disease, cholesterol, and even effects on glycemic responses.

The role of meat analogs can also help to meet SDG 2 "zero hunger", since meat consumption is expected to double by 2050, and there may be a lack of this type of food. If these products are replaced by meat analogues, the lack of protein foods could be avoided. The role of meat analogs can also help to meet SDG 2 "zero hunger", since meat consumption is expected to double by 2050, and there may be a lack of this type of food. If these products are replaced by meat analogues, the lack of protein foods could be avoided. The role of meat analogs can also help to meet SDG 2 "zero hunger", since meat consumption is expected to double by 2050, and there may be a lack of this type of food. If these products are replaced by meat analogues, the lack of protein foods could be avoided.

Research case study: Mixed solid-state fermentation of soy protein

Study design and research objectives

The study investigated a fermentation-based approach to creating meat-like characteristics in soy-protein products. The use of pigment-producing microorganisms and the incorporation of *Lactiplantibacillus plantarum* to improve product quality was examined. Fermentation parameters and inoculum levels were explored, and the resulting products were assessed for characteristics including color, texture, and flavor. The authors also investigated pigment properties and compared volatile flavor characteristics with fresh pork.

The study is relevant to halal meat-analogue development because it demonstrates how microbial processes can be used to engineer the appearance and sensory characteristics of plant proteins. However, the paper should be regarded as a technical case study in plant-based product development, not as proof that the final product has received halal certification or is nutritionally superior to conventional meat.

Reported findings

The principal findings available from the linked publication can be summarized as follows.

- Pigmentation: The research identified the potential of pigments produced by R. mucilaginosa and M. purpureus to improve the meat-like appearance of fermented soy-protein products.
- Mixed-culture fermentation: The researchers investigated the coexistence of the selected microorganisms and reported a beneficial role for L. plantarum in improving aspects of fermentation-product quality.

- Texture and flavor: The study explored changes in the texture and flavor profile of fermented soy proteins to bring the product closer to meat-like characteristics.
- Product-development potential: The authors proposed mixed solid-state fermentation as a promising approach to creating plant-based meat analogues with improved sensory properties.

The accessible publication record does not justify assigning exact percentage changes to hardness, chewiness, amino acids, vitamins, phenolics, or antinutrients in this review. Such values should be taken from the full article's tables and figures before being quoted.

Table 2. Case-study findings and their implications

Research component	Interpretation of the published study	Relevance to product development
R. mucilaginosa	Investigated as a pigment-producing microorganism	Potential contribution to meat-like coloration
M. purpureus	Investigated as a source of red pigments	Potential contribution to reddish appearance; requires toxin screening
L. plantarum	Included in mixed fermentation to improve product quality	Potential contribution to texture and flavor modification
Fermentation parameters	Time, temperature and inoculum conditions were explored	Process optimization and reproducibility
Color, texture and flavor	Evaluated as indicators of resemblance to meat	Product quality and consumer acceptance
Volatile flavor profile	Examined in relation to fresh pork	Understanding similarities and differences in aroma

Conclusions

Fermented meat analogs are considered an alternative to traditional meat products. The fermentative process is being studied to improve the nutritional and sensory attributes of these products. The review provides studies related to the preparation of meat analogues produced by fermentation and how the process can modify nutrients and organoleptic properties.

Sensory

- Decrease in the hardness of meat analogues produced by fermentation.
- Reduced lightness of fermented meat analogues as well as increased redness.
- Improved overall flavor and greater global acceptance by reducing off-flavors of grass or bean. However, in some cases, unpleasant notes were produced. The improvement in flavor is related to the increase in volatile compounds in the fermented samples.
- Reduction of antinutrients such as phytic acid as a consequence of the activity of phytase or the inhibitors of phytic acid of the strains used in fermentation.

Nutritional

- Increase in the content of amino acids and peptides as a result of the degradation of proteins by proteolysis.
- The fiber and vitamin content was increased, albeit minimally, but no significant differences were found with respect to the nonfermented meat analogues.

- Increased content of phenolic compounds after fermentation.
- Reduced saturated fat content as a consequence of the lipase content produced by the fermentative process.
- Fermented meat analogs can help reduce prevalent diseases such as obesity, cholesterol, or hypertension, being able to participate in the fulfillment of certain SDGs, such as SDG 13 "Adopt urgent measures to combat climate change and its effects", SDG 3 "Health and well being", and SDG 2 “Zero Hunger.”

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(I-10) A LOOK AT PHARMACEUTICAL R&D EFFORTS IN TURKIYE

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Abstract

Drug discovery and development is a multi-stage innovation process spanning from R&D activities to patents, and from preclinical and clinical development to regulatory approval. It is important to examine how the growth in Turkiye's pharmaceutical R&D capacity translates into outputs at various stages of the innovation chain; this requires a holistic assessment of R&D capacity and incentives, pharmaceutical patents, Phase I–III clinical trials, and regulatory indicators, alongside a review of the development stages reached by novel therapeutic candidates originating in Turkiye.

Data from Turkish Statistical Institute (TURKSTAT), the Turkish Medicines and Medical Devices Agency (TITCK), the Turkish Patent and Trademark Office (TURKPATENT), and the Pharmaceutical Manufacturers Association of Turkiye (IEIS) serve as the sources for information regarding pharmaceutical R&D capacity and incentives, domestic patent applications and registrations, initial Phase I–III clinical trial applications, and new product licenses.

An increase is observed in Turkiye's pharmaceutical R&D capacity, the incentives provided, and clinical research activity. However, development across the different stages of the innovation chain is uneven. Targeted patent analysis reveals that, in addition to small molecules, candidates involving diverse therapeutic approaches—such as peptides/proteins, monoclonal antibodies, oligonucleotides, vaccines, and gene/cell therapies—hold a significant place.

Although notable progress has been observed in Turkiye's pharmaceutical R&D ecosystem in recent years, evaluating the various stages of the innovation chain together reveals that this development is not uniform. Turkiye's current position in pharmaceutical innovation must be assessed not merely based on research and patent outputs, but by considering these outputs in conjunction with the processes of advanced development and transformation into commercial products.

Keywords: Drug discovery; pharmaceutical innovation; pharmaceutical patents; clinical development.

(I-11) BIOLOGICALLY DERIVED REGENERATIVE INGREDIENTS IN MODERN COSMETICS: EMERGING HALAL CRITICAL POINTS AND SHARIAH CONSIDERATIONS

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Abstract

The cosmetic and aesthetic industry is rapidly adopting biologically derived regenerative ingredients, particularly extracellular vesicles, exosomes, polydeoxyribonucleotides, and polynucleotides. These materials are increasingly used in skin rejuvenation, tissue repair, anti-ageing, pigmentation management, and other regenerative applications. Unlike conventional cosmetic ingredients, they may originate from human, animal, microbial, or other biological sources and undergo complex processes involving cell culture, extraction, purification, fragmentation, and formulation. Their increasing use creates new challenges for halal assessment and raises questions that are not fully addressed by conventional approaches focused mainly on the identification of animal-derived ingredients.

This study aims to identify and systematically map the potential halal critical points associated with selected biologically derived regenerative cosmetic ingredients and to analyse emerging Shariah questions related to their sources, production processes, purification, transformation, and intended use. A structured review of scientific literature, available manufacturing information, regulatory documents, and relevant Islamic jurisprudential principles is used to examine the production pathways of these ingredients and identify points requiring halal verification or further Shariah consideration.

Preliminary analysis indicates that the principal halal critical points are concentrated in four areas: the biological origin of the starting material, the use of culture media and processing materials, the extent of purification or transformation from the original source, and the intended cosmetic or aesthetic mode of use. Human-derived materials, reproductive biological materials, cell secretions, and purified genetic materials raise particularly novel questions concerning purity, transformation, permissibility of use, and the relationship between the final ingredient and its biological origin.

The study provides an initial framework for evaluating these emerging ingredients and highlights areas requiring further scientific clarification and formal Shariah deliberation.

Keywords: halal cosmetics, regenerative ingredients, exosomes, polynucleotides, Shariah assessment

(I-12) BUILDING A TRUSTED HALAL VACCINE ECOSYSTEM: INTEGRATING SCIENCE, HALAL ASSURANCE AND PUBLIC TRUST

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Abstract

The growing demand for halal pharmaceuticals highlights the need to rethink how halal assurance is integrated into vaccine development and governance. Beyond ingredient-based considerations, building a trusted halal vaccine ecosystem requires the integration of science, halal assurance, and public trust across the entire vaccine lifecycle. This presentation explores how scientific advancement and halal governance can be systematically aligned from research and development, cell substrates, and manufacturing processes to quality assurance, regulation, certification, and post-market surveillance. It highlights how emerging vaccine technologies, including mRNA platforms and other biotechnologies, introduce both new opportunities and complex challenges for halal assurance frameworks. Central to this discussion is the need for harmonised standards, evidence-based policymaking, transparent communication, and effective engagement among stakeholders, including industry, regulators, halal certification bodies, healthcare professionals, and the public. These elements are essential in strengthening vaccine confidence and ensuring that halal assurance is not perceived as a standalone certification exercise, but as an integrated system of trust. Ultimately, by embedding science, halal assurance, and public trust within a unified ecosystem, halal can be positioned as a comprehensive framework for quality, ethics, and innovation. This approach not only enhances confidence among Muslim consumers but also contributes to more resilient, ethical, and inclusive global healthcare systems.

Keywords: Halal vaccines; Vaccine ecosystem; Public trust; Vaccine innovation, Integration

(I-13) BEYOND EFFICACY: COMPATIBILITY AS THE MISSING DIMENSION IN PHARMACEUTICAL AND THERAPEUTIC SUCCESS

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Abstract

Despite remarkable advances in pharmaceutical science, many patients continue to experience variable outcomes even when receiving treatments proven to be safe and effective. This presentation proposes that therapeutic success depends on a largely overlooked factor: compatibility. Moving beyond the traditional focus on efficacy and safety, it introduces the Compatibility Principle, a systems-based framework that views healing as the result of alignment between four interconnected dimensions: physical compatibility between the medicine and the body, mental compatibility reflected in trust, acceptance, and adherence, spiritual compatibility grounded in personal values and halal-tayyib living, and the synergistic compatibility that emerges when these dimensions work together harmoniously. Drawing on systems medicine, psychoneuroimmunology, patient-centered care, and the Halalopathy framework, the presentation explores how trust, meaning, ethical congruence, and lifestyle factors can influence biological responses and therapeutic outcomes. It challenges the prevailing assumption that pharmaceutical effectiveness is determined solely by molecular action and argues that true therapeutic success arises when treatment is compatible with the whole human being. By integrating scientific rigor with ethical and spiritual dimensions of health, this framework offers a novel perspective for pharmaceutical innovation, personalized medicine, and sustainable healthcare, opening new pathways toward treatments that are not only effective, but also accepted, trusted, and transformative.

Keywords: Compatibility, Personalized medicine, Holistic healthcare, Halalopathy, Lifeytylopathy

(I-14) FROM HALAL TO TAYYIB: NANOEMULSIONS AS A PLATFORM FOR SAFE AND SUSTAINABLE COSMETIC INNOVATION

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Abstract

Halal cosmetics are typically assessed based on ingredient origin, while the Tayyib dimension additionally requires evidence of safety, efficacy, and environmental responsibility. This paper consolidates findings from nanoemulsion research and evaluates their overall suitability for halal cosmetic development according to these criteria. Four research directions were examined: a fish by-product and lemon oil nanoemulsion, an optimized nutrient nanoemulsion, ionic liquid lemon oil nanoemulsions, and computationally screened natural deep eutectic solvents. The fish by-product and lemon oil system presents the strongest case for cosmetic application. It produced fine, uniform droplets at mildly acidic pH and exhibited strong antioxidant, anti-inflammatory, and broad antibacterial activity without toxicity to normal skin cells. Furthermore, it accelerated wound closure and skin regeneration in adult zebrafish at concentrations that did not cause acute mortality, indicating potential for skin-repair products. The optimization study demonstrated that droplet quality is highly sensitive to solute load, providing a practical design guideline for cosmetic bases containing electrolytes. The natural deep eutectic solvents offer candidate plant-based phases, provided that the fatty acid origin is verified. Overall, the findings suggest that nanoemulsions based on plant oils and fish by-products are promising, waste-valorizing platforms for halal cosmetics and can link halal ingredient selection to measurable Tayyib performance. Suitability for finished products has not yet been established, as the origin and skin tolerance of surfactants and co-surfactants must be verified, surfactant levels should be minimized where possible, and long-term stability must be confirmed. Further steps include assessment of human skin tolerance, skin penetration, allergenicity, and halal certification. This presentation highlights the promise of nanomaterials, particularly nanoemulsions, as a platform for halal cosmetics applications.

Keywords: halal cosmetics, Tayyib, Nanoemulsion, Fish by-products, Lemon oil

(I-15) ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY OF HALAL FOOD SAFETY

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Abstract

Halal food safety, traditionally understood as a notion confined to a product's religious legitimacy, has in contemporary debates expanded to encompass the safety, quality, and sustainability of the entire supply chain from farm to fork. This study examines halal food safety along the axis of economic and environmental sustainability, demonstrating that the concept of halal converges with the Qur'anic principle of "Tayyib" (clean, healthy, of good quality) and thereby aligns with modern food safety standards. Islam's principles of stewardship, mizan (balance), and the prohibition of waste (israf) ground sustainability not merely as a technical requirement but as a moral obligation.

The sector's rapid growth has produced a series of structural problems: fragmented standardization among certification bodies, insufficient traceability and contamination risks within multi-stage global supply chains, the exclusion of production's environmental impacts -water, energy, carbon emissions, and waste -from oversight, and increasing food waste. These problems create a marked gap between normative claim and actual practice within a tradition in which the prohibition of waste is explicitly enjoined.

A review of the literature shows that three fields - halal studies, food safety and supply chain management, and environmental sustainability - have developed largely independently, leaving a significant research gap at their intersection. By rendering this gap visible, the study argues for an integrated conceptual framework and discusses its strategic importance for economic resilience, reduced environmental footprint, and the food security of Muslim societies alongside global sustainability goals.

Keywords: Halal Food, Food Safety, Economic Sustainability, Environmental Sustainability, Supply Chain

(I-16) THE HALAL ECONOMY ECOSYSTEM: A HALAL VALUE CHAIN PERSPECTIVE

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Abstract

The concept of halal has long been understood primarily in terms of the compliance of a product's ingredients and production processes with Islamic principles. Institutionally, this understanding has largely taken the form of product standardisation and halal certification. However, the globalisation of production and trade networks, the growing complexity of supply chains, and the diversification of halal product and service sectors have rendered assessments focused solely on the final product insufficient. These developments have brought greater attention to the halal value chain approach, which seeks to preserve halal integrity from source to final consumer. The halal value chain entails adherence to halal principles throughout all stages of a product or service, from sourcing raw materials and securing financing to production, processing, packaging, storage, logistics, distribution, marketing, and final consumption. It therefore constitutes a broader framework that encompasses, but is not limited to, the halal supply chain. Alongside halal sourcing and logistics, production technologies, quality control, traceability, standardisation, certification, and accreditation are integral components of this framework. In this respect, the halal value chain can be understood as an integrated halal assurance management framework designed to safeguard halal integrity from source to consumer. This study aims to identify the core components of an integrated halal economy ecosystem through the lens of the halal value chain. Drawing on document analysis, it examines the literature on halal value and supply chains alongside relevant international standards and institutional reports. The study argues that the effective operation of the halal value chain requires more than technical procedures: it also depends on an institutional halal policy and a corresponding governance structure. Qualified personnel, including members of halal advisory boards, halal compliance officers, and auditors, together with training, auditing, and traceability mechanisms, are essential to the continuity of this structure. The study's central premise is that the halal economy cannot be reduced to an aggregation of separate halal product and service sectors. Rather, food, pharmaceuticals, cosmetics, tourism, and other halal sectors need to be integrated with Islamic finance, takaful, standardisation, certification, accreditation, technology, and human capital. From this perspective, the halal value chain forms the operational backbone of a halal network connecting diverse sectors and stakeholders and, more broadly, of the halal economy ecosystem. The study thus links the development of the halal economy to the preservation of halal integrity throughout economic activity, rather than merely to an increase in the number of halal-certified products. This approach has the potential to broaden the predominantly food-centred understanding of halal and help bridge the existing gap between halal real-sector activities and Islamic finance. It can thereby support the integration of production, distribution, consumption, services, and finance, contributing to the development of a trustworthy, traceable, and sustainable halal economy ecosystem.

Keywords: Halal Value Chain, Halal Economy, Halal Ecosystem, Corporate Halal Policy, Halal Integrity, Halal Assurance System

INTRODUCTION: CONCEPTUAL AND THEORETICAL FRAMEWORK

The halal value chain is a holistic approach that seeks to establish and maintain compliance with halal principles throughout the processes extending from the procurement of inputs to the delivery of a product or service to the final consumer. This approach treats production, distribution, marketing, and consumption as interrelated activities. Its primary objective is to safeguard halal integrity at every stage of the chain, thereby ensuring that products and services meet Muslim consumers' religious requirements and fostering confidence in their compliance. The halal value chain requires close links between halal supply chains, logistics, market structures, products and services, and Islamic finance. Activities such as packaging, storage, and transportation are integral to this structure, as they preserve halal status beyond the production stage. Alongside the physical movement of products, the value chain approach encompasses the institutional arrangements, financial relationships, and assurance mechanisms that support halal compliance. Although its functions overlap with those of halal assurance management systems, it provides a broader analytical framework for examining relationships between different actors and processes. Implementing this framework at the organisational level requires a clearly defined corporate halal policy, together with mechanisms for assigning responsibilities, exercising oversight, and conducting audits to put that policy into practice. Identifying critical control points in production, service delivery, and procurement processes enables the management of risks that may affect halal compliance. Certification and traceability mechanisms support the verification and ongoing monitoring of compliance, while accreditation strengthens confidence in the competence of conformity assessment bodies. Depending on an organisation's activities, scale, and applicable regulations, halal advisory boards, halal compliance officers, and auditors may assume responsibilities within this structure. The halal value chain thus operates as a system in which processes extending from source to consumer are managed in accordance with a common policy, and halal integrity is supported by clearly assigned organisational responsibilities. (Amir & Tjibto Subroto, 2019, ss. 14-22; Cumhur Başkanlığı Finans Ofisi, 2022, ss. 156-169).

Islamic economics denotes an approach that examines economic activities within the framework of Islamic legal and ethical principles, with a view to promoting justice, social welfare, and the efficient use of resources. It envisages an economic order grounded in real economic activity that supports the circulation of wealth and the equitable distribution of prosperity. Islamic finance, as the financial expression of this approach, prioritises compliance with Shariah principles in the mobilisation, deployment, and management of funds. Its normative framework rests on the provisions of Islamic law governing contracts and financial relationships, particularly those of fiqh al-muʿāmalāt (Islamic jurisprudence concerning transactions). Alongside the prohibition of ribā, its core requirements include avoiding gharar (uncertainty) and jahālah (lack of knowledge concerning contractual particulars) to an extent that affects contractual validity, as well as gambling, deception, and unjust gain. Conversely, mutual consent, clarity, fulfilment of contractual obligations, and the linkage of earnings to legitimate economic activity and associated responsibility are fundamental principles. Although profit and risk sharing are prominent in partnership-based transactions, Islamic finance also encompasses trade- and lease-based arrangements. While the terms 'interest-free finance' and 'participation finance' emphasise different aspects of this framework, the concepts of the halal economy and halal finance foreground halal compliance in economic activity. Islamic economics is also described as a participatory economy, while some studies employ the terms 'halal economy' and 'halal finance' to refer to the economic and financial dimensions, respectively.

Islamic economics comprises a body of principles derived from the Qur'an and Sunnah and consistent with the provisions of Islamic jurisprudence governing economic life. Grounded in justice and equity,

this approach emphasises adherence to contracts, fulfilment of trusts, mutual confidence, cooperation, consultation, and the protection of property rights. Its fundamental principles include the prohibition of interest-bearing transactions, the linkage of financing to real economic activity, and the equitable distribution of income and wealth. One of its principal distinctions from conventional finance is its reliance on lawful trade, leasing, and partnership arrangements rather than interest-bearing borrowing. Nevertheless, Islamic economics neither rejects borrowing altogether nor envisages an exclusively equity-based system.

In Islamic law, the legitimacy of income is conditional upon its basis in labour or capital. Lawful earnings arise either from the actual expenditure of labour or from the deployment of capital in production through the assumption of commercial risk; returns on capital generated solely by the passage of time, without the assumption of risk, are regarded as falling within the scope of ribā. This principle establishes a direct link between the legitimacy of the source of financing and that of the production process (Ada, 2026; Ayub, 2017). It has been emphasised that the Qur'anic concept of ṭayyibāt encompasses both halal consumption and earning income through lawful means (Gül, 2010, ss. 27-28). The hadith stating that people will be asked on the Day of Judgement how they earned their wealth and where they spent it (al-Tirmidhī, "Ṣifat al-qiyāmah", 1) shows that earning and spending are interconnected aspects of accountability. For an economic actor seeking full halal compliance, this means not only avoiding non-halal products but also refraining from financial arrangements that contravene Islamic law when halal alternatives are available. (Ada, 2026).

The halal value chain has gained prominence in recent years, particularly through academic research and practical initiatives in Indonesia and Malaysia. Drawing on the value chain approach in the business and strategic management literature, this framework views production and service activities as an integrated system encompassing the procurement and transformation of inputs and the generation of outputs. How financial, human, and physical resources are used within this system affects costs, value creation, and profitability. Effective management of value chain activities can improve organisational performance, provide a competitive advantage, and support the sustainability of operations. The halal value chain combines this management approach with the objective of ensuring and maintaining compliance with halal principles throughout all processes. Implementing the halal value chain requires assessing not only raw materials but also processing technologies, storage and transportation conditions, marketing strategies, and advertising content for halal compliance. This approach encompasses both primary activities and support activities, such as corporate management and human resources. Aligning management and organisational structures with halal assurance principles, training employees, and respecting workers' rights are therefore complementary measures that help embed halal compliance across the organisation. The halal value chain can also be understood as a network connecting procurement with management, quality assurance, traceability, standardisation, and certification. Within this framework, the halal supply chain is one component of the broader value chain. Links with Islamic finance, service provision, and information technology infrastructure further strengthen its cross-sectoral character. However, the concentration of halal research and practice in the food sector may limit efforts to address halal integrity across the wider economic and social lives of Muslims. (Amir & Tjibto Subroto, 2019; Antonio vd., 2020; Noordin vd., 2009).

METHODS

This study adopts a conceptual and normative research approach based on document analysis. It examines the relationships between the halal value chain, the halal supply chain, and Islamic finance

to identify the key components of an integrated halal economy ecosystem. The sources comprise relevant academic publications, halal compliance standards, and institutional policy documents. In particular, the OIC/SMIIC 18:2021 Halal Quality Management System standard and the Participation Finance Strategy Document 2022–2025 serve as key references for examining the integration of finance with halal sectors (*SMIIC*, 2021).

The analysis focused on the scope of halal integrity, the role of financing within the value chain, corporate halal policy and governance mechanisms, and cross-sectoral connections. Conceptual discussions and findings on existing practices were examined together along these dimensions. Examples from Indonesia, Malaysia, and Türkiye, drawn solely from the available literature and documents, were used to illustrate different aspects of the relationship between halal sectors and Islamic finance. These assessments informed a proposed conceptual model that links financing, production, distribution, and consumption within a common framework of halal compliance. The study does not involve fieldwork or empirical testing of the proposed model. Its potential effects on trust, efficiency, and sectoral growth are therefore presented as propositions to be tested in future research.

FINDINGS

In Türkiye, efforts to develop halal infrastructure and practices can be viewed as steps towards establishing a halal value chain that ensures compliance with halal requirements and preserves halal integrity at every stage of a product or service (Cumhur Başkanlığı Finans Ofisi, 2022, ss. 156-169). The halal value chain is an integrated industry-wide endeavour encompassing inputs, production, distribution, marketing, and consumption. It comprises a range of components, including halal procurement, halal food quality and hygiene, halal storage and logistics, halal management and tracking systems, halal inspection and labelling, halal quality control, and halal traceability (Amir & Tjibto Subroto, 2019). The Halal Accreditation Agency (HAK) was established in Türkiye in 2017 under Law No. 7060 to support the development of the halal value chain. The agency aims to accredit halal conformity assessment bodies, ensure that they operate in accordance with international standards, and thereby secure national and international recognition of the certificates they issue. HAK is a public legal entity with administrative and financial autonomy and a special budget. It is the sole institution authorised to provide halal accreditation services in Türkiye and bases its accreditation activities on SMIIC standards (Uygunluk Değerlendirmesi Derneği, 2022, ss. 34-35).

Existing halal compliance systems leave a significant gap in this respect. In Indonesia, it has been argued that halal product legislation does not include financing among its certification criteria, even though the means by which capital is obtained should also comply with halal principles. From this perspective, financial resources, as an ‘upstream’ input to production, should be included as an indicator in halal certification (Ada, 2026; Ahyar, 2020, s. 124). Similarly, JAKIM’s halal certification procedures in Malaysia do not require applicants to use Islamic sources of financing (Ada, 2026; Muhamed vd., 2014, s. 124) In Malaysia, only 54.1% of halal businesses receive bank financing, and less than a quarter of that financing (21.9%) comes from halal finance, providing quantitative evidence of the same disconnect. It has been observed that, although rigorous procedures are applied when granting halal status to production and services, the financial dimension does not receive the same level of scrutiny (Tağtekin, 2023, ss. 436, 440). In Türkiye, conventional banking facilities may likewise be used to finance activities within the halal value chain, with no requirement to work with participation finance institutions. As a result, participation finance plays only a limited role in halal value creation (Cumhur Başkanlığı Finans Ofisi, 2022, s. 164; Tağtekin, 2023, s. 437).

The view that halal compliance should encompass sources of financing and financial management alongside production and service processes also finds support in halal standards. The OIC/SMIIC 18:2021 Halal Quality Management System standard excludes from its scope financial services based entirely on interest, as well as financial and insurance institutions that do not operate in accordance with Islamic rules. Clause 6.1.1 requires financial management to be addressed in accordance with Islamic requirements when planning for risks and opportunities, while Clause 7.1.5 requires the organisation's capital and source of income to be halal (*SMIIC*, 2021, s. md. 1, 6.1.1, 7.1.5).

The halal park envisaged in the Participation Finance Strategy Document can be viewed as the spatial expression of this model. It brings participation banks, takaful providers, participation leasing companies, guarantee institutions, and fintech firms together with manufacturers, logistics providers, technology parks, universities, and regulatory and supervisory bodies within a shared ecosystem. It also envisages the use of participation finance products from the establishment stage onwards (Tağtekin, 2023, ss. 437-440). In Türkiye, participation banking accounted for 8.6% of the banking sector in 2022, with a target of 15% set for 2025. However, this target was not achieved. The sector's total assets grew by approximately 45% in 2025, reaching TRY 4 trillion, yet its share of the banking system remained at around 9%. Sector representatives now envisage increasing this share to 15% initially and subsequently to 25–30%. (*TKBB Yönetim Kurulu Başkanı Akben*, 2025; *Ziraat Katılım Genel Müdürü Özdemir*, 2025).

DISCUSSION

Discrepancies can arise between the theoretical principles of Islamic finance and its practices. One reason is that Islamic financial institutions operate within an economic and institutional environment in which interest-bearing transactions play a dominant role. Bringing theory and practice into closer alignment requires examining both financial transactions and the processes surrounding them in light of Islamic principles. The value chain approach offers a means of examining these processes holistically, from design and procurement to production, marketing, and after-sales activities. By addressing the relationships between activities and the creation of value, this approach can strengthen organisational self-assessment and process transparency when supported by appropriate information and audit mechanisms. Adapting the value chain approach to Islamic finance can help monitor compliance with Islamic principles at both the transaction and process levels, keep customers informed, and strengthen trust in institutions. An analytical framework developed along these lines can assess economic organisation, business management, financing, investment, consumption, and marketing against a common set of principles. To measure compliance, however, the general value chain model must be supported by clearly defined Shariah criteria and verifiable indicators. The halal value chain seeks to preserve halal compliance throughout the production and distribution of goods and services and to ensure that internal and external organisational relationships are governed by a halal policy and assurance mechanisms. It thus extends a product-centred understanding of halal to encompass supply processes and institutional relationships. In this context, integrating halal studies with research on Islamic economics and finance, and developing the concept of an 'Islamic economics and finance value chain', are important steps. This framework aims to bring the principles of justice, equity, sharing, and participation into economic activity by addressing human, social, and environmental responsibilities alongside Shariah compliance. The value chain model can therefore provide a common analytical basis for strengthening the links between halal sectors and Islamic finance in both research and practice.(Şimşek, 2021).

The key distinguishing feature of the proposed model is the position of financing within the chain. In

Porter's value chain, financing is treated as a support activity within firm infrastructure and contributes indirectly to value creation. In the Islamic economics and finance value chain, by contrast, financing is a foundational link that directly determines the chain's legitimacy. A production process initiated with non-halal sources of funding cannot acquire legitimacy as a whole through technical compliance at subsequent stages. Under this approach, halal compliance shifts from 'an output verified after the fact' to 'a system characteristic established from the outset' (Ada, 2026).

In a value chain that begins with financing, primary activities are reshaped according to Islamic legal criteria. Cost and lead time are not the sole considerations in procuring inputs; their origin, halal compliance records, and traceability are also taken into account. During production, cross-contamination is prevented, production lines are segregated, and in-process audits are conducted. Halal products are kept separate from non-halal products during storage and distribution, preserving halal integrity through to delivery to the consumer. In marketing and sales, halal claims must be accurate and transparent. Post-sale measures include certification renewal, consumer feedback, and product recalls in cases of non-compliance. These mechanisms ensure that halal compliance is maintained over time (Ada, 2026; Kamaci, 2024, ss. 106-111) Support activities are also redefined according to the same criteria. Within firm infrastructure, which encompasses finance, accounting, legal affairs, planning, and quality management, halal financing serves as a strategic filter that determines which activities the firm considers legitimate for inclusion in the value chain. In human resource management, embedding a halal culture and training employees, together with traceability systems developed through technological innovation, ensure transparency throughout the chain (Ada, 2026; Kamaci, 2024, ss. 110-113).

Within this framework, the participation finance system serves not only as a financier or intermediary for the halal sector but also as a partner that complements halal practices. It is expected to be involved at every stage, from procurement and production to service provision and the delivery of goods. It should also provide guidance, acting as a 'financial compass' (Tağtekin, 2023, s. 440). This approach also requires the redesign of halal conformity assessment processes. Accordingly, the halal compliance system should include the following elements:

1. Pre-qualification stage: Sources of financing should be disclosed and assessed for Shariah compliance before production begins.
2. System audit: Financial risk management, interest-free financing structures, and investment ethics should be audited as part of the halal assurance system.
3. Ongoing surveillance: Changes in financing structures should be monitored regularly. (Ada, 2026).
4. This model extends beyond the internal value chain of a single firm. Vertical linkages determine the continuity of halal compliance across successive stages, from financing to final consumption. Where these linkages are weak, non-compliance at earlier stages may call halal integrity into question, even if the final product is halal-certified. Horizontal linkages, in turn, refer to shared certification and supply infrastructure across sectors such as food, cosmetics, pharmaceuticals, tourism, and logistics. By serving multiple sectors through these linkages, participation finance institutions can help coordinate the wider ecosystem through economies of scale, knowledge sharing, and standardisation (Ada, 2026).

One way to achieve the target of a 15% share for participation banking in Türkiye's banking sector is to integrate participation finance with the halal value chain. This indicates that developing financial

products alone is insufficient to support the growth of participation finance. A structural link with the halal value chain could provide the sector with a lasting source of demand in the real economy. If the ecosystem is developed around clear targets and measurable outcomes, the halal industry could become a source of national competitive advantage. The growth of halal sectors and participation finance should therefore be understood as two aspects of the same structural transformation, rather than as separate objectives.

CONCLUSION

The Islamic economics and finance value chain is an analytical framework that completes the halal value chain by incorporating financing as a link. It extends Shariah compliance from the product level to the process and institutional levels. The legitimacy of income, the validity of contracts, risk and profit sharing, workers' rights, and environmental responsibility become common criteria linking financing, production, distribution, marketing, and consumption. This framework brings the disconnect between halal sectors and participation finance into focus as an institutional issue. Bridging this gap depends on designing certification, financing, and audit processes together.

This integration could also contribute to the growth of the Islamic economy and participation finance. Financing halal production through participation finance instruments creates new and stable opportunities for their use in the real sector. Channelling Islamic finance into the halal industry supports halal production while also creating new investment opportunities that generate halal income. Integrating the halal industry with Islamic finance strengthens consumer trust in halal products, which in turn encourages wider use of Islamic financial products. Businesses in halal sectors offer participation finance institutions opportunities to expand their asset base and reach. Initiatives such as halal parks could play an important role in raising the sector's profile and increasing its market share, particularly in participation banking.

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(I-17) HALAL FOOD AND ISLAMIC FINANCE: A BUSINESS OPPORTUNITY OR PART OF A SHARED VALUE SYSTEM?

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Abstract

The fact that human beings' need for food is a biological necessity does not mean that this need can be met without rules. Different civilizations have developed various sets of rules governing food consumption. These rules have sometimes been shaped by geographical conditions, sometimes by religion, and sometimes by factors independent of both. Consequently, different civilizations have developed distinct dietary practices. However, meeting this fundamental human need has sometimes required access to financing as well. The ways in which this financing has been provided have also varied across civilizations.

Islamic civilization, too, has developed its own set of rules, regulating food as a biological necessity while also establishing limits concerning the financing required to meet this need. It is precisely at this point that food and finance intersect. In the pre-modern banking era, Muslims developed various institutions addressing this intersection. With the expansion of the banking sector, it has become natural to expect Islamic finance to assume this role. But does Islamic finance genuinely fulfill this role? And if so, how does it manage the tension between the values it embodies and the pursuit of profit? In seeking to address these questions, this presentation aims to highlight the problems that may arise from viewing food and finance either as independent domains or, alternatively, as interconnected components of an integrated whole that mutually reinforce one another.

Keywords: Halal Food, Islamic Finance, Islamic Civilisation, Food Financing, Values–Profit Relationship.

(I-18) THE PHILOSOPHICAL BACKGROUND OF HALAL TOURISM AND ITS STRATEGIC IMPORTANCE FOR MUSLIM SOCIETIES

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Abstract

This study explores the significance of a "halal lifestyle" for Muslim societies, examining the concepts of zero waste and frugal living—as essential components of such a lifestyle—through the lens of the epistemological foundations of the Islamic faith. For a Muslim, a halal lifestyle is of vital importance; one strives to remain within the bounds of what is permissible (*halal*) in every aspect of life—whether in daily routines, professional endeavors, eating and drinking, sleep, leisure and recreation, or even tourism and vacations. This is because, for a Muslim, the notion that religion and daily life could be separate spheres is impossible. Every Muslim, mindful of their role as a servant of God, understands that all their actions and behaviors—and even the thoughts passing through their minds or hearts—are known to their Lord and are duly recorded.

"Halal tourism" refers to the practice of tourism—an industry centered on leisure—within a framework that adheres to Islamic principles. An individual who engages in this form of tourism is known as a "halal-conscious tourist." Such a tourist typically has two primary concerns. The first is the desire to avoid any conflict with their religious beliefs; consequently, they expect access to halal food, a halal-compliant environment, and entertainment that aligns with their faith. The second concern is the desire to fulfill their religious obligations—such as performing daily prayers or observing fasts—without disruption; therefore, they expect the provision of a well-equipped environment and the necessary facilities to carry out these acts of worship. Furthermore, in line with the strong emphasis found in Islamic teachings—reflecting both the command of Allah (SWT) and the counsel of the Prophet (PBUH)—it is also expected that such individuals remain mindful of avoiding waste, embracing a "zero-waste" approach.

Keywords: Halal Tourism, Halal Sensitive Tourist, Zero Waste, Muslim, Islam, Tourism

(I-19) GLOBAL BRANDS AND NEW OPPORTUNITIES IN HALAL TOURISM: THE FUTURE OF HALAL-CONCEPT HOSPITALITY

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Abstract

Dear Prof. Dr. Orhan Batman, distinguished speakers, honourable guests; I greet you all with respect.

Today I would like to discuss halal-concept hospitality as a question of branding. In this field there is demand, there is a product and there is experience; yet the missing link is very often the brand.

Let us begin with demand. According to this year's Mastercard–CrescentRating index, international Muslim arrivals are expected to reach 196 million in 2025, ten million above earlier projections. Total travel spending is forecast to reach 230 billion US dollars by 2030. Türkiye holds a strong position in this picture: Malaysia leads with 83 points, while Türkiye shares second place with Saudi Arabia and Indonesia at 79 points.

Now let us place this picture next to global hospitality. Today, the hotel industry is concentrated in the hands of a few large groups. Marriott is the world's largest chain with 9,266 hotels and around 1.68 million rooms; Hilton has reached 8,342 hotels and about 1.25 million rooms. IHG operates 6,963 hotels and more than one million rooms. Wyndham, with roughly 8,389 hotels and 869,000 rooms, and Accor, with 5,836 hotels and 881,000 rooms in more than 95 countries, are also at the top of the list. Accor alone manages 45 brands.

These groups share a common secret: they grow as brand owners, not as property owners. Franchise and management agreements allow them to add new brands and rooms without owning the real estate. They have developed a separate brand for every segment, from luxury to economy and from lifestyle to extended stay. Yet there is a striking gap: as far as we know, among the hundreds of brands of these five major groups, there is no halal-concept brand that directly addresses the 196-million-strong Muslim travel market. This gap has opened a historic opportunity for regional players.

The first to see this opportunity came from the Gulf. The Rotana group developed the Rayhaan brand within its portfolio and positioned it as the region's first alcohol-free hospitality brand. What matters here is that the halal concept is not left to individual hotels but tied to a measurable brand standard. To join the brand, Rayhaan requires at least 120 rooms and minimum room sizes of 28 square metres for four-star and 32 square metres for five-star properties. Even the brand name carries a story: rayhaan refers to a fragrant plant mentioned in the Qur'an and in the prophetic tradition.

The second important example is Retaj from Qatar. Founded in Doha in 2004, Retaj operates according to Islamic principles and does not allow alcohol or smoking in its hotels. Data shared in the brand's early years also showed the commercial value of this model: while average occupancy in Doha was 63 per cent, occupancy in Retaj hotels was 87 per cent. Today Retaj has a segmented structure with sub-brands such as the five-star Retaj Royale, the four-star Retaj Al Rayyan and Retaj Leisure and Resort.

The third example is Shaza. What distinguishes Shaza is that it connects the halal concept to global distribution and loyalty systems. As a member of the Global Hotel Alliance, the brand is part of a network of more than 500 hotels worldwide through the Discovery loyalty programme. It has also signed a global pricing and distribution agreement with WebBeds for all Shaza and Mysk hotels. The

most important point for Türkiye is this: from 2027 onwards, Shaza has identified Türkiye, Central Asia and North Africa as priority markets for its international growth.

These examples teach us four lessons. The first is standards: the halal concept should rest on measurable brand criteria, not on self-declaration. The second is segmentation: rather than a single hotel type, separate sub-brands are needed for luxury, midscale, city and resort products. The third is distribution: a brand cannot grow unless it is connected to global booking channels and loyalty programmes. The fourth is a scalable business model: without a structure that can grow through franchise and management agreements, halal hospitality remains at the level of local ventures.

Let us now turn to Türkiye. Türkiye is one of the most experienced countries in the world in the halal-concept resort product. However, this experience has not been turned into a brand. Academic studies show that the number of halal-concept hotels in Türkiye is approaching 200, yet there is no specific regulation for these hotels in tourism legislation, and the figure is based on hotels' own self-description. There are domestic chains made up of a few hotels; however, there is not yet an international halal hospitality brand that has crossed borders and is able to franchise. A study analysing guest reviews also points to the problem: guests state that staff are insufficiently trained, that privacy needs more attention and that prices are higher than in other concepts. These are, in fact, different faces of the absence of a brand standard.

Here I would also like to connect with the main theme of our session. A strong halal brand can write the prevention of waste into its standards. The principle "Eat and drink, but do not waste" is a sustainability commitment that stems from the very values of a halal hospitality brand. A brand that measures and reduces food waste in its all-inclusive operations both lowers its costs and tells its guests a story that cannot be imitated.

In the coming period, one of two paths awaits us. Either Türkiye will develop its own halal hospitality brands with their standards, sub-brands and international distribution networks, and carry this experience to the Balkans, Central Asia and the Muslim population in Europe; or the strong brands of the Gulf will come to Türkiye and we will remain merely a host country in this market. In fact, the two paths are not mutually exclusive. Cooperation with global brands can accelerate the learning process of domestic brands. What matters is that this transformation is managed in a planned way. At this point, SMIIC standards offer a common language; our esteemed speaker Yasin Zülfikaroğlu will present this topic to us in detail.

Let me conclude as follows. Until now, halal-concept hospitality has mostly been defined by what it does not offer. The halal brand of the future, however, will be known for what it does offer: trust, standards, family, peace of mind and a waste-free understanding of service. Türkiye has both the product and the experience; now it is time to turn them into a brand.

Thank you all for your attention.

Keywords: Halal tourism, halal-concept hospitality, branding, hotel brand, brand standards, zero waste

(I-20) OIC/SMIIC STANDARDS ON HALAL TOURISM SERVICES -

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Abstract

The Standards and Metrology Institute for Islamic Countries (SMIIC), an affiliated institution of the OIC, aims to promote harmonization and uniformity in the fields of standardization, metrology and laboratory testing among its Member States. It also facilitates education, training and technical assistance to strengthen their capacities in these areas.

OIC/SMIIC Standards are developed through the Institute's Technical Committees, which are composed of experts nominated by SMIIC Member States. Through their active participation in the technical standardization process, these experts contribute to the development of common standards intended for adoption and use by OIC Member States and relevant stakeholders worldwide.

Within this framework, Technical Committee 5 (TC 5) – Tourism and Related Issues was established to address standardization needs in the tourism sector. One of its initial activities was the development of a standard addressing Halal tourism services. Following its submission to the Member States for review and approval, the draft was adopted and subsequently published on 22 December 2019 as OIC/SMIIC 9:2019 – Halal Tourism Services – General Requirements.

Keywords: SMIIC, Tourism

(I-21) BEYOND THE BROCHURE: HOW HALAL TOURISM, HERITAGE AND CULTURAL TRADITION BUILDS SUSTAINABLE COMMUNITIES

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Abstract

Halal tourism has emerged as one of the fastest-growing segments of the global tourism industry. It refers to travel experiences that facilitate the observance of Islamic principles while remaining welcoming and accessible to travellers from all backgrounds. The concept encompasses the availability of halal food, prayer facilities, privacy considerations, modest environments, and family-friendly services. More importantly, halal tourism reflects a broader commitment to ethical hospitality, respect for cultural values, and responsible tourism practices.

The significance of halal tourism is reinforced by the rapid growth of the global Muslim population, which now exceeds 1.9 billion people. This market represents substantial economic potential, with Muslim travellers contributing hundreds of billions of dollars to global tourism expenditure annually. Key source markets include the Gulf Cooperation Council countries, Indonesia, Malaysia, Türkiye, and increasingly Muslim communities in Europe and North America. As a result, destinations worldwide are recognizing the importance of adapting their services to accommodate the needs and expectations of Muslim travellers.

For many Muslim travellers, tourism represents more than recreation and leisure. Travel becomes an opportunity to reconnect with cultural roots, strengthen spiritual understanding, and explore the rich heritage of Islamic civilization. Visits to historical mosques, centres of learning, heritage sites, and cultural landmarks allow travellers to gain a deeper appreciation of the historical contributions of Muslim societies in fields such as education, science, architecture, and art. These experiences foster cultural awareness and strengthen a sense of identity while promoting intercultural dialogue and mutual respect.

One of the most attractive aspects of halal tourism is its culinary heritage. Food serves as a powerful medium for cultural exchange and storytelling. Traditional halal cuisine reflects centuries of history, trade, migration, and local customs. Whether it is Moroccan tagine, Turkish kebab, Indonesian rendang, or Malaysian street food, each dish offers insights into the values and traditions of the communities that created it. Culinary tourism not only enriches visitor experiences but also supports local producers, preserves traditional recipes, and creates sustainable economic opportunities within communities.

Architecture and cultural heritage also play a central role in halal tourism. Islamic architectural achievements continue to inspire admiration for their beauty, innovation, and functionality. Historic mosques, palaces, madrasas, and other heritage structures demonstrate remarkable advances in engineering, artistic expression, and urban planning. These sites provide valuable educational experiences for visitors while encouraging preservation efforts that protect cultural assets for future

generations.

Interestingly, halal tourism is no longer confined to Muslim-majority destinations. Countries such as Japan, South Korea, Thailand, and several European nations have introduced Muslim-friendly services, including halal-certified restaurants, dedicated prayer facilities, and specialized travel information. These initiatives demonstrate that halal tourism is evolving into a global movement that emphasizes inclusivity, cultural sensitivity, and respect for diversity. By accommodating the needs of Muslim travellers, destinations can attract new markets while fostering greater cross-cultural understanding.

Alongside the growth of halal tourism, ethical tourism has gained increasing attention as a framework for responsible travel and sustainable development. Ethical tourism seeks to redefine the relationship between tourists and destinations by emphasizing environmental stewardship, cultural preservation, and social responsibility. Unlike traditional tourism models that often focus primarily on profitability, ethical tourism promotes practices that respect local communities, protect natural resources, and generate long-term benefits for society.

Ethical tourism contributes significantly to sustainable development by aligning tourism activities with broader environmental and social objectives. It encourages responsible consumption, biodiversity conservation, resource efficiency, and climate resilience. By minimizing negative impacts and maximizing positive contributions, ethical tourism supports the achievement of sustainable development goals while ensuring that tourism remains viable for future generations.

The social benefits of ethical tourism are equally important. Through the promotion of cultural preservation and community participation, tourism can empower local populations and strengthen social cohesion. Ethical tourism provides opportunities for marginalized and underrepresented groups to share their traditions, heritage, and local knowledge with visitors. This process enhances cultural pride, revitalizes local identities, and ensures that development initiatives reflect community aspirations and priorities.

From an economic perspective, ethical tourism enhances resilience by ensuring that tourism revenues remain within local communities. Community-based tourism models create employment opportunities, support local entrepreneurs, and encourage the growth of small and medium-sized enterprises. Artisans, guides, accommodation providers, farmers, and service operators all benefit when tourism development prioritizes local ownership and participation. As a result, communities become less vulnerable to external economic shocks and more capable of sustaining long-term prosperity.

A fundamental principle of ethical tourism is local involvement and empowerment. When communities actively participate in planning, managing, and benefiting from tourism activities, they develop a stronger sense of ownership and responsibility. Supporting local entrepreneurship and community-led initiatives not only drives economic growth but also strengthens social capital, enhances community well-being, and contributes to positive social transformation.

The example of James Bond Island in Krabi, Thailand, illustrates both the opportunities and challenges associated with tourism development. While the destination has generated considerable economic benefits through tourism, it has also faced concerns related to environmental degradation, overcrowding, and resource management. This case highlights the importance of applying ethical

tourism principles to achieve a balance between economic growth, environmental conservation, and community welfare. Sustainable tourism success depends on maintaining this delicate balance over the long term.

In conclusion, halal tourism represents a dynamic integration of faith, culture, heritage, and economic development. It is not merely a specialized niche but a significant force influencing the future of global tourism. At the same time, ethical tourism provides a transformational framework that promotes sustainability, inclusivity, and social responsibility. Together, these approaches preserve cultural heritage, empower local communities, strengthen economic resilience, and foster greater understanding among diverse societies. Nevertheless, challenges such as inconsistent halal standards, cultural commodification, and sustainability concerns require ongoing collaboration among governments, industry stakeholders, academics, and local communities.

Ultimately, the future of tourism must be guided by principles that balance profitability with responsibility, development with conservation, and growth with social equity. By embracing ethical tourism and the values embodied in halal tourism, we can create a more sustainable, inclusive, and resilient tourism industry that benefits both travellers and host communities alike.

(I-22) DEVELOPMENT OF HALAL HEALTHCARE SERVICES CRITERIA FOR HOSPITALS IN TÜRKIYE WITHIN HALAL MEDICAL TOURISM

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Abstract

The increasing importance of cultural and religious sensitivity in healthcare highlights the need for standards addressing Muslim patients' expectations. This study aimed to develop a criteria-based framework for halal healthcare services in hospitals in Türkiye within the scope of halal medical tourism. The project was conducted collaboratively by Lokman Hekim University and Süleyman Demirel University, involving 19 researchers. Working groups were established for questionnaire development, literature review, criteria development, and examination of international practices. Data were collected from 427 citizens and 236 patients. A 29-item patient expectations questionnaire was prepared in Turkish, English, and Arabic, and data were collected online and face-to-face at Lokman Hekim University Ankara Hospital. Factor analysis identified three dimensions: faith sensitivity, gender sensitivity, and faith-based technical arrangements. Survey findings, relevant literature, international standards, and practices informed the criteria pool. The criteria were refined through two online workshops, one face-to-face workshop, research team evaluations, and contributions from the Rufaida nursing community. A framework comprising 40 criteria across seven dimensions was developed: worship facilities (11), halal and safe food (8), gender sensitivity and patient privacy (7), medical care and treatment (2), medicines and medical supplies (3), spiritual counseling and end-of-life services (5), and institutional policies (4). The criteria were classified into basic, intermediate, and advanced implementation levels. At the final workshop held on October 2, 2026, decisions concerning the scope, applicability, clarity, and measurability of the criteria were unanimously approved. It was decided to transform the criteria into a standardization proposal entitled “Halal Healthcare Services – General Requirements for Hospitals.” The collaboratively developed framework provides a structured basis for integrating religious sensitivities into hospital service delivery and institutional quality management. The final report has been submitted to the Standards and Metrology Institute for Islamic Countries as a standardization proposal.

Keywords: Halal Healthcare Services, Halal Medical Tourism, Hospital Criteria, Healthcare Quality, Standardization

(I-23) FINANCIAL SUSTAINABILITY OF HALAL HEALTH SERVICES

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Abstract

DEFINITION OF HALAL (permitted) AND HARAM (forbidden)

Halaal should be understood from its wide comprehensive perspective. The fiqh principles provide guidance. Halaal is the default position, and haram is incidental and fully defined. What is not haram is halaal except in certain exceptional circumstances known by the jurists.

الأصلُ في الأشياءِ الإباحةُ. الأصلُ في الأشياءِ الحِلُّ، والتَّحريمُ عارِضٌ

We therefore understand that the field of halaal is very wide and expansive. It adapts to changing circumstances of time, place and circumstances. I prefer using the term mubaah for medical applications.

DEFINITION OF HEALTH and HEALTH CARE

The narrowest definition of health is negative as absence of disease. The widest definition is that health is a positive state of being that involves physical, social, psychological, and spiritual well-being.

Health care is defined as prevention of disease and promotion of health. Disease prevention has three levels: primary (prevent disease from occurring), secondary (detect and treat disease to stop or slow its progression), tertiary (deal disabilities following disease). Note that disease treatment is part of disease prevention because treatment of an earlier stage of a disease prevents the later stages in the progression.

DEFINITION OF LEVELS OF HEALTH CARE SERVICE

Resources for disease prevention and health promotion are limited so we must choose priorities. There are 4 levels of priorities.

• Necessities, dharuraat, are health services for ensuring basic survival like nutrition and antibiotics for a severe infection. Necessities are services that should be a human right for every citizen fulfilled by the family, the community or the state

• Needs, hajiyaat, are health services for removing hardships and difficulties to make life easier but are not necessary for basic survival.

• Compliments, mukamillaat, and embellishments, tahsinaat, are health services beyond necessities and needs but extend and improve on them to ensure life with dignity.

• Excesses, israfaat, and wastage, tabdhiraat, are health services that go beyond the three levels above and are generally condemned when they take resources away from the necessities.

Classification of specific medical procedures according to the levels explained above is not easy and unanimity is difficult to reach. The level of wealth and resources, level of medical technology and its

efficacy as well as the needs for equity must be taken into consideration for each local society.

FINANCING HEALTH CARE

Financial responsibility depends on the level of health care. The responsibility can be on the individual or the community. The health care provider cannot be at the same the source of financing we should keep care provision separate from care financing in two separate parallel organizations that work in coordination: Waqf, Health insurance, and Zakat funds. The provider should charge the price than can cover the actual costs to ensure financial stability.

Dharuurat is a family/community/public responsibility as part of Governance and is from zakat or Sadaqat. Needs are like dharuuraat but at a lower level of priority. It is the duty of Halaal health care to mobilize community resources for those who cannot afford.

Compliments and embellishments are the individual's responsibility if he can afford. Excesses and waste are individual responsibility, but the Halaal health care services should educate the community to avoid the excesses because resources used here could have helped individuals who cannot afford. The Halaal health provider can provide these services to those who can afford but should encourage them to contribute a similar amount to dharuraat services for those who cannot afford.

Cooperative health insurance with no individual profit or investment interests is in my view the best way of financing health care. It succeeds if coverage is very wide in the millions to ensure mutual self-help, takaful. In a large cooperative health insurance scheme individuals pay roughly equal premiums, but treatment services are determined by need. In this way those with fewer demands on the resources subsidize those with more demands which fulfills takaful in an efficient way. This also fulfills takaful in a dignified way since those with high health needs do not feel that they are getting direct sadaqat from the others.

Health care costs are excessive and should be curbed. One of the strategic objectives of Halaal health services should be minimizing health care costs. Health is an essential social commodity and should not be part of the profit-oriented economy. The provider of the services should be paid at cost. Determining the true cost of health services is not easy and much research is needed. The medical services market unlike the free market does not have competition among sellers that ensures the lowest price for the sovereign consumer and who is free to choose the best price for him or her. In the medical market there is the pain and suffering of the consumer that do not allow the luxury to compare offerings by different providers. The consumer also does not have full information to decide because the provider who is the hospital or doctor determines the problem (diagnosis), the needed services (surgery), the cost (hospital bill), and supplies the service (operation). The consumer has no say in the process and must accept whatever is offered. This is unlike the free market in which the need is auto-determined by the consumer. The seller does not interfere in this process. The seller only provides a menu of services with different costs, and the consumer makes his or her choices.

(I-24) AN EVALUATION OF THE RESPONSIBILITIES OF OFFICE IN TERMS OF TIME AND MEANS: WITHIN THE FRAMEWORK OF NIZAM AL-MULK'S SIYASATNAME

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Abstract

The rapid pace of development and change experienced by humanity affects the established structures, values, and administrative approaches of states and institutions and may, at times, lead to the erosion of ethical and administrative principles. Contemporary processes such as liberal governance, the free-market economy, and competition make it necessary to reconsider the concepts of responsibility, trust, and public service among officeholders in both public and private institutions. Principles such as loyalty, trust, justice, merit, and competence, which have maintained their importance in state and society for centuries, also constitute essential foundations of a sustainable and reliable economic and social order.

Responsibility attached to public office is multidimensional. On the one hand, officeholders are expected to observe justice, act with integrity, and serve society; on the other hand, they are responsible for using the time, authority, and resources entrusted to them efficiently, avoiding waste, developing beneficial projects, and directing available resources toward the public good. From a contemporary perspective, this approach can be related to discussions on sustainable halal economy, particularly in terms of ethical governance, responsible use of resources, trust, accountability, and the prevention of waste.

Nizam al-Mulk, the renowned vizier of the Great Seljuk Empire, addressed the responsibility of public office in his Siyasatnama through legal and ethical, social and human, financial and administrative, as well as moral and spiritual dimensions, offering extensive advice to rulers and administrators. Drawing on these principles, which were formulated nearly a thousand years ago yet continue to retain their relevance, this study examines the responsibility of officeholders from the perspective of "time and resources." It further discusses the significance of justice, trust, merit, prevention of waste, and efficient use of resources within the framework of a sustainable halal economy.

Keywords: Nizam al-Mulk, Siyasatnama, Halal Economy, Public Responsibility, Ethical Governance

(I-25) ANTI-WASTEFULNESS AND THE ETHICS OF MODERATION (IʿTIDĀL) IN AL-MĀTURĪDĪ: A STUDY IN THE CONTEXT OF KITĀB AL-TAWḤĪD AND TAʾWĪLĀT AL-QURʾĀN

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Abstract

Iʿtidāl (moderation), one of the fundamental principles of ethical life in the Islamic intellectual tradition, refers to the maintenance of a balanced relationship between the individual and God, society, and nature. Isrāf (wastefulness), regarded as the opposite of this principle, is not limited to the unnecessary consumption of economic resources; rather, it encompasses all forms of excess that divert the material and spiritual means available to human beings from their intended purpose in creation. The Qur'an addresses isrāf in various contexts and frequently emphasizes the necessity of moderation in human conduct. In his work Taʾwīlāt al-Qurʾān, al-Māturīdī interprets the relevant verses by defining isrāf not merely as an individual failing but also as a mode of conduct that contravenes the principles of wisdom, justice, and responsibility.

In al-Māturīdī's system of thought, wisdom (ḥikma) is regarded as a fundamental characteristic of God's actions and the order of creation. Human actions, in turn, acquire ethical value insofar as they conform to this order of wisdom. Within this framework, reason is positioned as an epistemological instrument that enables human beings to comprehend the divine order, while the concepts of divine blessings (niʿma), gratitude (shukr), and trust (amāna) cultivate an awareness of responsibility toward the resources and opportunities entrusted to human beings. This responsibility encompasses a broad range of domains, extending from economic behavior and social relations to the use of environmental resources.

According to al-Māturīdī, divine blessings are both manifestations of divine grace and means of testing; therefore, human beings bear responsibility for all the resources and opportunities available to them. For him, gratitude does not merely consist in acknowledging the source of a blessing; it also entails using that blessing in accordance with its intended purpose in creation. Isrāf, by contrast, signifies the separation of a blessing from its underlying wisdom and the weakening of the awareness that it constitutes a divine trust. In this respect, al-Māturīdī's understanding of gratitude establishes a broad sphere of responsibility extending from the ethics of consumption to economic relations and the use of natural resources.

Thus, in al-Māturīdī's thought, the concept of isrāf signifies not only economic excess but also any form of conduct that violates the principles of wisdom, justice, and awareness of entrusted responsibility. Conversely, moderation (iʿtidāl) is regarded as a fundamental principle of both individual morality and social order.

Keywords: al-Māturīdī, wisdom, wastefulness, moderation, halal living.

(I-26) FROM "MICRO" PRUDENCE TO "MACRO" SUSTAINABILITY: ISLAMIC ECONOMIC ETHICS AND THE PREVENTION OF WASTE FROM THE PERSPECTIVE OF TADBIR AL-MANZIL

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Abstract

The ecological and economic challenges facing the contemporary global economy necessitate an evaluation of production and consumption processes not only in terms of efficiency and growth but also within the framework of ethical responsibility and sustainability. In this context, the prevention of waste, the prudent use of resources, and the promotion of intergenerational justice have emerged as central concerns of sustainable economic thought. This study aims to explore the historical and philosophical foundations of these concerns through Tadbir al-Manzil (household management), one of the principal disciplines of classical Islamic practical philosophy.

Employing a qualitative research approach based on document analysis and conceptual examination, the study investigates the relationships among household management, the acquisition and use of wealth, the balance between income and expenditure, moderation, contentment, and wastefulness in classical Islamic ethical thought. It argues that Tadbir al-Manzil is not merely a technical framework for managing the material needs of the household but also an ethical framework that regulates economic behavior through the principles of virtue, justice, and responsibility.

The central argument of this study is that the principles of prudence and moderation developed at the individual and household levels can provide a normative foundation for responsible consumption, resource conservation, and sustainable economic practices at the societal level. From this perspective, wastefulness is understood not merely as the unnecessary consumption of resources but also as a departure from moderation and ethical balance in economic behavior.

In conclusion, the study argues that the principles of management and consumption articulated at the micro level within classical Islamic economic ethics can offer a historical and ethical perspective on contemporary sustainability debates. Relating the Tadbir al-Manzil tradition to the contemporary halal economy may contribute to an understanding of halal principles that extends beyond the religious permissibility of products and transactions to encompass ethical responsibility in production, consumption, and resource utilization.

Keywords: Tadbir al-Manzil, Islamic Economic Ethics, Wastefulness, Moderation, Sustainable Economy, Halal Economy

SECTORAL SESSIONS

(S-01) INTRODUCING HTS — THE OIC/SMIIC HALAL TRACEABILITY SYSTEM

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Abstract

Member states have agreed that a common halal mark will be defined at the level of the international halal standardization body, yet far less attention has been given to what happens after the mark is chosen. Drawing on more than a decade of practical experience in national product tracking, marking and return systems, this presentation argues that a mark carries trust only to the extent that it can be verified, and that fragmented national verification arrangements quietly generate three forms of waste that a common mark alone cannot remove. The first is duplicated work: the same product is registered, marked and inspected repeatedly as it crosses borders, and inspectors and importers face several different codes and applications for a single item. The second is product loss: when a certificate is suspended or withdrawn and the affected consignments cannot be identified, entire stocks are recalled or destroyed rather than the specific batch concerned, which directly contradicts the zero-waste and resource-efficiency agenda of the halal economy. The third, and most damaging, is the erosion of trust: a single counterfeit or invalid mark weakens confidence in every product carrying the same symbol, and duplication of marks makes counterfeiting easier rather than harder. Experience from comparable national systems suggests that these effects are not resolved by stronger certification rules alone; they require a shared digital layer providing common definitions of company, certificate, product and scope, a continuously current certificate status, and a single point of verification accessible to authorities, inspectors, traders and consumers alike, while each country retains full authority over its own decisions and data. The central observation offered to participants is one of timing: verification designed together with the mark is straightforward and inexpensive, whereas verification added afterwards is costly, slow and rarely complete. The presentation closes with practical considerations for accreditation bodies, regulators and standardization institutions preparing for this stage.

Keywords: halal traceability, common halal mark, conformity verification, supply chain integrity, waste reduction

(S-02) HALAL FRIENDLY MEDICAL TOURISM: BUILDING A PATIENT-CENTERED HEALTHCARE ECOSYSTEM FOR MUSLIM TRAVELERS

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Abstract

Medical tourism has become a significant part of international healthcare, as patients cross borders seeking quality treatment, affordability, specialized expertise and shorter waiting times. For Muslim patients, destination choice is also shaped by whether hospitals and staff can accommodate their religious and cultural needs. This creates a distinct opportunity for hospitals and destinations to strengthen the patient experience they offer. This paper examines halal friendly medical tourism as a model that integrates clinical quality with services addressing the practical realities of Muslim patients and their accompanying families - assured halal food, prayer facilities, private and dignified care, culturally aware staff, family-friendly accommodation and access to spiritual support. The central argument is that this is not a matter of adding a few extra amenities, but of building a whole system that works together: hospitals, hotels, food service providers, travel facilitators, certification bodies and destination authorities operating to shared standards. The goal is for Muslim patients to receive the care they need without having to worry about whether their cultural and religious needs will be met. This requires clear service standards, staff training and transparent communication, so patients know what to expect and providers can deliver consistently. It is not enough to claim to be "Muslim-friendly" - the aim is to genuinely deliver on that promise, which in turn reflects good hospital and destination practice that benefits all patients, not only Muslim ones. Destinations that combine internationally recognized clinical standards with genuine cultural responsiveness are likely to be more appealing to Muslim patients and their families, while making medical tourism more inclusive overall. The paper concludes by proposing a coordinated framework - spanning certification, training and destination-level standards - as a practical step toward building this ecosystem.

Keywords: Halal friendly medical tourism, Muslim patients, cultural sensitivity, patient-centered care, healthcare ecosystem

(S-03) PERCEPTIONS OF HALAL QUALITY INFRASTRUCTURE AND ECOSYSTEM IN EUROPE: A CONSUMER PERSPECTIVE

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Abstract

Over the last few decades, the European halal market has grown incredibly fast, bringing a massive variety of halal-certified products and services to consumers. Past studies make it clear that Muslim consumers in Europe know a lot about halal concepts. However, there is a missing piece in the puzzle: what happens behind the scenes? This study moves past simple consumer awareness to look at the concrete halal quality infrastructure and the wider ecosystem that keeps these products on the market in the first place. The main goal of this research is to see how Muslim consumers across Europe view the systems meant to protect the halal value chain. Using data from a quantitative survey, the paper analyses what consumers think about the credibility and everyday effectiveness of current halal standards, certification, accreditation, lab testing, inspection, and traceability. A major focus is placed on whether consumers feel these rules are consistent from one certification body to another, alongside their specific expectations for how halal status should be verified and shared. Ultimately, the analysis connects these structural elements directly to consumer confidence. Early data shows that for everyday consumers; halal integrity is about much more than a logo on a package. Instead, they see tight certification, real transparency, clear traceability, and uniform standards as the actual foundation of trust. There is a strong, undeniable demand for better, more transparent tools to check a product's status at any point in the supply chain. These findings give a practical roadmap for building long-term trust and help stakeholders see what it really takes to push the European halal market forward today. Keywords: halal quality infrastructure, halal ecosystem, halal integrity, halal certification, consumer perception

Keywords: halal quality infrastructure, halal ecosystem, halal integrity, halal certification, consumer perception

(S-04) DRIVING A SUSTAINABLE HALAL ECONOMY IN AGRICULTURE THROUGH OIC/SMIIC STANDARDS

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Abstract

Agriculture represents a fundamental foundation of the halal economy, extending beyond primary production to food processing, traceability, quality assurance, market access and consumer confidence. However, achieving a sustainable and internationally connected halal agricultural sector requires common standards that address product quality, safety, authenticity and halal requirements across the value chain. This paper presents the standardization approach of the Standards and Metrology Institute for Islamic Countries through its Technical Committee on Agricultural Products as a case study of developing an agricultural standards ecosystem for the halal economy. The paper examines how agricultural standardization can support the transition from farm-level production to participation in global halal markets. It highlights the role of the Technical Committee in bringing together experts and national stakeholders to develop harmonized requirements for agricultural products and processes. The paper reviews selected standards and ongoing projects covering products such as dates, saffron, cottonseed meal and cake, processed harissa, date paste, henna and rose water, together with work addressing halal agricultural production and geographical indications. The findings demonstrate that agricultural standards can provide a structured foundation for improving consistency, quality, traceability and market confidence while supporting the integration of halal principles into agricultural production. The paper further identifies future opportunities for strengthening sustainable agriculture, specialized product standards, geographical indications and coordinated quality infrastructure across halal markets.

Keywords: Halal agriculture, agricultural standardization, halal quality infrastructure, sustainable halal economy, agricultural products, harmonization

(S-05) FROM POST-HALAL TO INSTITUTIONAL AMĀNAH: MAKING TRUST MEASURABLE ACROSS THE HALAL ECOSYSTEM

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Abstract

The global expansion of halal has created an increasingly complex ecosystem involving producers, certifiers, logistics providers, digital platforms, regulators, distributors and consumers. Certification remains indispensable, but it cannot by itself guarantee the continuity of the halal promise across such interconnected value chains. This presentation develops the concept of the post-halal era, which I introduced at the World Halal Summit in Istanbul in 2025. “Post-halal” does not mean the end or rejection of halal; it designates a new analytical perspective that moves beyond the conformity of individual products to examine the circulation of trust, responsibility and accountability throughout the entire halal ecosystem.

To address this challenge, the presentation proposes Institutional Amānah as both a governance framework and a practical business capability. Amānah is understood not simply as trust or personal integrity, but as an entrusted responsibility for which individuals and institutions must answer. Institutional Amānah translates this ethical principle into identifiable responsibilities, continuous traceability, credible evidence, transparent corrective mechanisms and measurable impact.

The presentation will introduce three possible operational instruments—an Amānah Assessment, Amānah Impact Indicators and a digital Trust Passport—and examine how they could strengthen buyer confidence, reduce reputational risk, support cross-border market access and contribute to the resilience of the global halal economy.

(S-06) PLAIN LANGUAGE IN HALAL STANDARDS: A NEW APPROACH TO ENHANCE CLARITY AND COMPLIANCE

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Abstract

The growing global halal industry requires not only strict compliance with religious and technical standards but also effective communication that ensures these standards are clearly understood and correctly implemented by diverse stakeholders. This paper introduces the concept of plain language—as defined by the International Plain Language Federation—into the domain of halal standards, proposing it as a critical yet underexplored dimension of halal governance and assurance. Plain language refers to communication that enables intended audiences to easily find, understand, and use information. While widely applied in regulatory, healthcare, and public service contexts, its integration into halal standardization remains limited. This study argues that the complexity, multilingual nature, and technical structure of existing halal standards may create barriers for stakeholders, including producers, auditors, consumers, and small and medium enterprises, potentially affecting compliance, trust, and market access. By analyzing selected halal standards and certification documents, this paper identifies key communication challenges, including ambiguity, inconsistent terminology, and inaccessible structure. It then proposes a framework for incorporating plain language principles into halal standards without compromising Shariah requirements or technical precision. The framework emphasizes clarity, usability, inclusivity, and accessibility, particularly for non-expert users and individuals with diverse linguistic and cognitive needs. The findings suggest that adopting plain language in halal standards can enhance transparency, improve compliance rates, reduce misinterpretation, and strengthen consumer confidence in halal certification systems. Furthermore, it supports inclusivity and aligns with global movements toward accessible and user-centered regulatory communication. This research contributes to the evolution of halal standardization by positioning plain language as a strategic tool for improving both the effectiveness and ethical integrity of halal communication. It calls for standard-setting bodies, certification agencies, and policymakers to integrate plain language principles into future revisions of halal standards, thereby advancing a more inclusive and globally accessible halal ecosystem.

Keywords: Halal standards, Plain language, Halal certification, Transparency, Compliance

(S-07) GREEN HAL-Q: ADVANCING HALAL QUALITY INFRASTRUCTURE THROUGH SCIENCE, INNOVATION AND SUSTAINABILITY

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Abstract

The global halal industry is increasingly expected to ensure not only religious compliance and product integrity, but also environmental responsibility, resource efficiency, and sustainable growth. In response to these emerging expectations, the Halal Science Center, Chulalongkorn University, is developing Green HAL-Q, a science-driven approach that integrates halal quality assurance with scientific verification, innovation, and sustainability principles. Green HAL-Q builds upon halal quality management by incorporating sustainability considerations into the identification, assessment, and management of critical points throughout the production process and supply chain. The framework emphasizes the role of halal forensic science and laboratory verification in strengthening product integrity, while integrating resource efficiency, waste reduction, environmental performance, and digital technologies into halal quality management. Scientific tools for detecting non-halal contamination, verifying ingredient origins, and assessing critical halal risks provide objective evidence to support more reliable and transparent decision-making. The ongoing development of Green HAL-Q also introduces sustainability indicators that can be integrated with halal assurance requirements. This approach enables organizations to identify halal, quality, and environmental risks within a more unified management framework, with the potential to reduce duplicated activities, minimize unnecessary resource consumption and waste, improve traceability, and strengthen operational efficiency. Green HAL-Q demonstrates how halal quality infrastructure can evolve beyond conventional compliance toward a more integrated, science-based, and sustainability-oriented ecosystem. By connecting halal science, quality management, technological innovation, and environmental responsibility, the framework aims to strengthen consumer trust while supporting responsible production and sustainable growth. Ultimately, Green HAL-Q offers a pathway toward a more resilient, transparent, and sustainable halal economy.

Keywords: Green HAL-Q, halal quality infrastructure, halal science, sustainability, sustainable halal economy

(S-08) HALAL ECONOMY AND SUSTAINABLE GROWTH TOWARDS DIGITAL

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Abstract

The HALAL economy has become a part of the world economy, covering things we eat, wear, and do every day. As more people around the world understand HALAL, it helps people make the right choices, reduce waste, and support growth that benefits everyone. Due to the tensions and changes in the current world economy, people involved in HALAL industries have taken steps to enhance and make the HALAL industries more visible and easier to understand, with add-ons in technology capacity. Advancing and upgrading information and the use of technology are some of the main tools and strategies to reach people worldwide. Technology plays one of the most important roles in helping people throughout the world understand and accept more information on matters related to HALAL. Technology has become a very important tool for products and services, encouraging better ways of understanding the whole HALAL ecosystem and also helping to explain waste management to people. People involved in HALAL industries, including procedures and certification bodies, with strong and confident assistance from SMIIC, have made HALAL more accessible to everyone. Steps have also been taken to deliver a strong message to users that waste also needs to be learned and understood in order to handle and avoid wastage. Using technology provides a better understanding of HALAL and helps avoid wastage while increasing the relevance and acceptance of HALAL practices. Technology has become a new and innovative solution that continues to develop and become a main tool, providing an easy gateway for people around the world to understand and follow HALAL practices with complete and updated information. Both Muslims and non-Muslims can benefit from HALAL through technology, particularly in relation to products, responsible choices, and better use of resources. They will also gain a better understanding of saving, controlling, and minimizing waste, which can become another important role of HALAL practices. With the current situation in the world, technology has become a more reliable tool to reach people and users, helping them understand, accept, and learn about HALAL knowledge completely, starting from understanding to usage. New ideas and computers are very important for the growth of the HALAL economy. Websites and apps can help share information, support production, trading, selling, and daily life. These solutions can also help reduce waste and make processes more efficient. Today, the growing HALAL economy gives people who work in the industry a chance to work together and use sustainability as a tool for growth. If we can reduce waste and help businesses, it can make the HALAL economy stronger and beneficial for everyone. Technology can also support better traceability and monitoring throughout the HALAL supply chain. Digital systems can help businesses track products, manage resources, and identify areas where waste can be reduced. At the same time, digital platforms can provide consumers with clearer information about HALAL products and responsible consumption. This can increase trust, improve efficiency, and encourage more sustainable practices within the HALAL economy.

(S-09) COMPLIANT, AND STILL REJECTED: THE HIDDEN WASTE DRAINING A TRILLION-DOLLAR HALAL ECONOMY

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Abstract

The halal economy counts its waste at the end, in what gets thrown away. Its larger losses happen earlier, and more quietly, before anyone consumes anything. A shipment can leave origin fully compliant and lose its eligibility on the way. Sometimes the certification is not recognized in the destination market. Sometimes a certifying body's recognition has lapsed. Sometimes a corridor closes, and the alternative route runs under different rules. The goods still arrive. They are simply no longer eligible when they do, which brings rejection, re-export, spoilage, write-off, good food and real capital destroyed, not because anything was unsafe, but because no one could confirm eligibility in time. The sector rarely counts this as waste. It should. What this really is, before a logistics problem, is a verification problem. A certificate that cannot be verified across a border is not proof of anything. It is a claim, and claims do not clear customs. The remedy sits ahead of the movement, not after it, establishing whether a given product, from a given supplier, into a given market, is genuinely eligible under the rules that apply there, before it ships, without displacing the certification bodies whose authority it verifies. OneAgrix does not certify. It verifies that existing certifications hold up, across jurisdictions, as an auditable layer beneath the trade, tracing every determination to an official source. The work behind it is the subject of a United States patent application with 2025 priority and a corresponding international (PCT) filing.

Keywords: Halal, Kosher, Vegan; eligibility verification; cross-border recognition; traceability; food waste; trade infrastructure

(S-10) AMANAH: WHAT THE CARAVANSERAI KNEW THAT THE CARBON LEDGER DOES NOT

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Abstract

Sustainability, as tourism currently defines it, is a subtraction problem. Measure the harm, offset it, demonstrate you took slightly less than you gave. It is a framework built on the assumption that travel is fundamentally extractive and the best we can do is extract less. Muslim civilisation built a different model, and built it in stone. The caravanserai was not a hotel. Endowed as waqf and sustained by attached revenues rather than the traveller's purse, it housed merchants and pilgrims for free while circulating wealth into the surrounding towns. It treated the traveller as a trust and the locality as a beneficiary, and it did so for centuries without a single impact report. Behind it sat a principle the sustainability sector is still groping toward: amanah. What you hold, you hold in trust. That is not a lower bar than sustainability. It is a considerably higher one. This paper argues that the halal travel sector has been borrowing a vocabulary it does not need; meanwhile, it already has a tried-and-tested framework of its own. That framework speaks directly to the failures now visible across global tourism: resident backlash in saturated cities, a fixation on visitor numbers rather than on how much of what visitors spend reaches local people, and the collapse of trust in unverifiable green claims. Grounded in Halal Travel Guide's decade of small-group journeys through Asia, the Balkans, and the rest of the world, this study tests whether amanah can be put to work rather than merely invoked. Drawing on both qualitative and quantitative evidence, it traces how much of a traveller's payment stays in the destination, examines how faith-led itineraries carry travellers toward regions written out of the tourist map, and sets out where the approach reaches its limits. The proposition for destinations, operators and policymakers is that the most credible future for sustainable tourism may already be standing, half-ruined, along the old roads where caravanserais once functioned.

(S-11) BUILDING HUMAN CAPITAL FOR A SUSTAINABLE HALAL ECONOMY THROUGH CAPACITY BUILDING AND E-LEARNING: THE SMIIC EXPERIENCE

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Abstract

The global halal economy has evolved into one of the world's fastest-growing sectors, spanning food, pharmaceuticals, cosmetics, tourism, logistics, finance, and lifestyle services. While significant attention has been devoted to sustainable production, responsible consumption, and environmental stewardship, one critical dimension of sustainability remains underexplored: the development of competent human capital capable of implementing halal standards effectively, consistently, and sustainably. Human capital should therefore be recognized as a strategic driver of sustainable growth and a fundamental component of a resilient halal quality infrastructure. Drawing on practical experience at the Standards and Metrology Institute for Islamic Countries, this presentation examines how structured halal training and capacity-building programmes can strengthen human capital across the halal ecosystem. Particular attention is given to the development of the Training Center and the Academy of the Standards and Metrology Institute for Islamic Countries as platforms for structured professional training, e- learning, online assessment, certification, and wider knowledge sharing. The experience demonstrates that combining standards-based training with e-learning and continuous professional development can expand access to specialized knowledge, strengthen knowledge transfer, support more consistent implementation of halal requirements, and reduce duplication and gaps in capacity building. The presentation proposes an integrated capacity-building approach based on five elements: harmonized standards, professional competencies, digital knowledge sharing, and continuous learning. It concludes that eliminating waste in the halal economy should extend beyond material and resource efficiency to include the prevention of knowledge loss, duplication, and gaps in professional capacity. Investing systematically in human capital can strengthen trust, improve efficiency, and contribute to sustainable growth across the global halal ecosystem.

Keywords: Human Capital, Capacity Building, Halal Training, e-Learning, Halal Quality Infrastructure

(S-12) COMPARATIVE ANALYSIS OF THE ADVANTAGES AND DISADVANTAGES OF MECHANICAL HALAL POULTRY SLAUGHTERING COMPARED TO TRADITIONAL MANUAL SLAUGHTERING

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Abstract

Halal slaughtering of poultry involves specific religious and technical requirements that ensure the compliance of meat with Islamic rulings. Traditionally, halal slaughtering is performed manually, strictly adhering to the rules regarding animal consciousness, severing the cervical blood vessels, and reciting the Tasmiyah. However, with the development of the food industry in recent decades, mechanical slaughtering methods have been increasingly applied, enabling greater efficiency and mass production. This raises questions regarding the compliance of mechanical slaughtering with Islamic rulings and applicable halal standards (e.g. OIC/SMIIC, MS, and others). This paper analyzes the advantages and disadvantages of mechanical halal slaughtering of poultry in comparison to traditional manual slaughtering. The focus is on key aspects such as process speed, compliance control, adherence to religious rulings, meat quality, and economic factors. The objective of the paper is to provide an objective insight into which method better satisfies halal production standards, taking into account technological and ethical challenges. When it comes to the act of halal slaughtering itself, it represents the process of severing the major blood vessels in the neck, so that the animal bleeds out in the shortest possible time, thereby ensuring animal welfare. Manual slaughtering has been used since time immemorial. Today, it remains virtually the only method used for slaughtering large and small ruminants, but this is not the case with poultry slaughtering. Over the past few decades, chicken meat production has recorded by far the highest growth on a global level. The reasons for this are numerous: a fast production cycle, high feed conversion rates, and economic factors that have brought this sector to a leading position in the meat industry and the consumer’s appetite for a versatile and convenient product. Following the expansion of primary production, the need arose to expand slaughterhouse capacities and introduce more modern processing methods. One of the greatest challenges was increasing the speed and efficiency of the slaughtering act itself, which led to the systemic implementation of mechanical poultry slaughtering. The only difference in the entire production process lies precisely in the method of bleeding itself (manual or mechanical), while all other operations before and after that act remain identical. The advantages of mechanical slaughtering are numerous, but there are also certain drawbacks. For the meat industry, a mechanical slaughtering device does not represent a major investment, especially considering that the machine replaces workers previously employed on the line. On average, one machine replaces 4 to 10 people, depending on line capacity and speed. Generally, there are two primary methods of mechanical poultry slaughtering: "Frontal cut" (frontal cut). Slaughtering is performed with a rotating blade from the underside of the neck. This method is almost identical in its methodology to manual slaughtering. Side-of-the-neck slaughtering, where fixed blades are positioned on two sides of the machine, performing the act of slaughtering from both sides of the neck simultaneously. The biggest problem

with mechanical slaughtering is variations in the size of individual birds, as the machine is usually adjusted to the average size of the flock. In such situations, improper slaughtering often occurs — the cut is too low on larger birds or too high on smaller ones. With smaller birds, this is a more frequent problem because the cut is often made across the head, which is completely improper and contrary to halal standard requirements as well as animal welfare principles. An additional risk in mechanical slaughtering is the possibility that the animal dies prior to the actual slaughter due to preceding procedures, including inadequate stunning or mechanical injury. Halal standards explicitly prohibit such practice and require that stunning, if applied, must be reversible and must not cause the death of the animal prior to slaughter. To overcome obstacles related to variations in poultry size and ensure the completeness of the process, modern industrial lines apply a back-up system (Back-up staff). Positioned at the end of the mechanical slaughtering segment is a qualified and trained Muslim whose task is to immediately manually slaughter all birds that the machine missed, insufficiently cut, or improperly sliced due to their dimensions. This combination of automation and human supervision ensures that no inadequately cut bird proceeds further into the processing pipeline. In the context of halal certification and auditing, mechanical slaughtering requires additional documentation, continuous process monitoring, equipment validation, and training for the personnel performing control, supervision, and corrections. Any deviation from prescribed conditions can lead to non-compliance and the loss of the product's halal status. The greatest advantages of mechanical slaughtering are exceptional speed, reduced labor requirements on the slaughter line, and ultimately, a lower unit cost of the finished product. Additionally, the reduced need for labor benefits processing plants located in regions or locations where it is difficult to recruit sufficient number of qualified Muslim operatives. In conclusion, although mechanical poultry slaughtering enables greater efficiency and economic advantages, manual slaughtering remains the most reliable method for achieving full compliance with halal standards. Mechanical systems can be acceptable only under strict control, the deployment of backup personnel, clear procedures, and constant supervision, thereby ensuring the preservation of halal principles and consumer trust.

Keywords: mechanical poultry slaughtering; manual slaughtering; animal welfare

(S-13) HUMAN MILK BANKS IN ISLAMIC LAW: MILK KINSHIP, MEDICAL NEED, AND A PROPOSED FRAMEWORK

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Abstract

Breast milk supports infant nutrition and health, especially for premature and low-birthweight babies. When a mother's milk is unavailable or insufficient, milk from another woman may be needed. Islamic law allows a woman to nurse another woman's child, directly or with expressed milk. However, qualifying feeding establishes milk kinship (radaʻah), which creates permanent marriage prohibitions between specified relatives. Jurists consider the child's age, how the milk reaches the child, and the amount or number of feedings; some conditions differ between schools of law.

Human milk banks collect, process, store, and distribute donated milk in countries including Brazil, the United Kingdom, and the United States. Their practices raise questions beyond clinical safety. Whether banks may buy or sell milk, how they charge for services, and the risks of unregulated online or black-market trade require separate ethical and legal assessment. Unidentified donors, pooled milk, and incomplete records may prevent families from knowing which children have become milk relatives. These concerns help explain why many Muslim scholars and institutions oppose conventional milk banks.

This paper examines the religious basis of milk kinship, the medical need for donor milk, and the limits of current milk-bank models. It proposes a framework for consideration when a compelling clinical need cannot be met through the mother's milk or an identifiable wet nurse. The framework includes medical assessment, donor screening, informed consent, verified donor identities held confidentially, separation of each donor's milk, documented delivery to each infant, secure long-term records of milk relationships, a lawful way to check for prohibited marriages, and oversight of sourcing and fees. Clinical specialists, health authorities, and qualified Islamic jurists would supervise the system.

These safeguards are offered for scholarly evaluation, not as an existing permission for milk banks. Any practical model would require review by competent Shariah authorities while protecting both infant health and milk kinship.

(S-14) ZERO-WASTE MANAGEMENT IN HALAL VALUE CHAINS: A CONCEPTUAL FRAMEWORK BASED ON OIC/SMIIC STANDARDS

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Abstract

This study examines the relationship between waste prevention in halal value chains and circular economy principles in the context of OIC/SMIIC standards. Its significance lies in linking the existing conformity mechanisms of the halal quality infrastructure with resource efficiency, food loss and waste, by-product utilisation, and circular material flows. Waste is addressed not merely as the quantity of materials sent for disposal, but as the preventable loss of food, raw materials, water, energy, packaging, and economic value. A qualitative documentary review and directed content analysis were conducted. The dataset comprised OIC/SMIIC standards; ISO 14001, ISO 59004, ISO 59010, ISO 59014, and ISO 59020; the Food Loss and Waste Accounting and Reporting Standard; Türkiye's Zero Waste Regulation; and relevant academic literature. The findings indicate that OIC/SMIIC standards provide a robust basis for maintaining halal integrity throughout the sourcing of inputs, production, equipment, storage, transportation, retail, service provision, quality management, and conformity assessment. This basis can support zero-waste management through process control, segregation, documented information, verification, and defined responsibilities. However, no published OIC/SMIIC standard establishing an integrated zero-waste management system was identified in the standards corpus examined. In particular, source prevention, the management of surplus products and returns, by-product utilisation, circular use of materials, and the measurement of resource losses are not addressed within an integrated management system perspective. The study synthesises the complementary elements of halal and circular economy standards into a five-component conceptual framework: value-chain resource and loss mapping; circular flows controlled to preserve halal integrity; a waste-prevention and value-retention hierarchy; a decision protocol for recovery pathways; and measurement, governance, and conformity assessment. Its original contribution is to position halal integrity not as a constraint on circular practices, but as a control criterion for decisions concerning reuse, redistribution, recovery, and disposal. The proposed framework provides an analytical basis for integrating a zero-waste perspective into OIC/SMIIC standards and for developing future implementation guidance. Keywords: Halal value chains; zero-waste management; circular economy; OIC/SMIIC standards; halal quality infrastructure.

Keywords: Halal value chains, zero-waste management, circular economy, OIC/SMIIC standards, halal quality infrastructure

NOTES

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