# Journal
## of halal quality and certification

Vol. 4 · No. 1 · June / juni

ISSN 2831-1469 (Print)

ISSN 2831-1477 (Online)

# JOURNAL
# OF HALAL QUALITY AND CERTIFICATION

**JOURNAL OF HALAL QUALITY AND CERTIFICATION**
**Printed edition** ISSN 2831-1469 (Print)
**Online edition** | **Online izdanje**: https://journal.halal.ba/ ISSN 2831-1477 (Online)

# Foreword

Dear Readers,

It is our pleasure to present Volume 4, Issue 1 of the Journal of Halal Quality and Certification, which continues to serve as an international scientific platform dedicated to advancing knowledge, best practices, and professional dialogue in the fields of halal quality, certification, standardization, and related sectors.

In recent years, halal has emerged as an important area of research across a wide range of scientific disciplines. As technological advancements continue to transform industry, new challenges arise for the academic community and researchers, particularly in the areas of Islamic jurisprudence, food technology, pharmaceutical and cosmetic sciences, as well as sustainability. At the same time, the development of information technologies and artificial intelligence is creating new opportunities for a more systematic and automated approach to halal certification, traceability, and the dissemination of information on halal products and services.

The papers published in this issue reflect the interdisciplinary nature of contemporary halal research, encompassing topics from food science, medicine, economics, management, standardization, and information technology. This diversity of topics confirms that halal today extends far beyond matters of food consumption and is increasingly becoming a subject of scientific inquiry that connects ethics, health, sustainability, technology, and global economic development.

We sincerely thank the authors for their valuable contributions, the reviewers for their rigorous and constructive evaluations, and the members of the Editorial and Scientific Boards for their continuous support. We hope that this issue will stimulate further research, dialogue, and collaboration aimed at promoting excellence, credibility, and innovation in the field of halal quality and certification.

*Prof. dr. Midhat Jašić, Editor-in-Chief*
*Dr. sc. Muamer Mandra, Guest Editor*

# Contents

**Zinka Hojkurić Rahmanović, Berin Rahmanović, Adnan Čučuković, Mirela Čučuković, Adnan Alijagić, Damir Alihodžić, Mehmed Sultanović, Munevera Begić**
IN VITRO STUDY OF THE ANTIFUNGAL ACTIVITY OF 10% PROPOLIS EXTRACT IN PROPYLENE GLYCOL ON CANDIDA ALBICANS.....3

**Ismet Kalić**
STRATEGIC FINANCIAL MANAGEMENT IN THE FUNCTION OF LONG-TERM SUSTAINABLE DEVELOPMENT OF THE HALAL INDUSTRY IN THE CONTEXT OF DIGITALIZATION AND ARTIFICIAL INTELLIGENCE.....11

**Çağrı Cankurtaran**
TOWARDS A GLOBALLY COHERENT OIC HALAL ECOSYSTEM: POSITIONING SMIIC AS SCHEME OWNER AND IFHAB AS MRA PLATFORM.....19

**Amela Semić, Ema Obralić, Belmin Poljić, Arman Hodžić**
INTEGRATION OF ISLAMIC ETHICAL PRINCIPLES INTO BUSINESS STRATEGIES OF SUSTAINABLE ECONOMIC SYSTEMS.....31

**Jawad Alzeer**
HALALOPATHY: A SYSTEMS-BASED BRIDGE BETWEEN MODERN MEDICINE AND PROPHETIC MEDICINE.....37

**Aldijana Omerović, Azra Sinanović, Ragib Spahić**
ENHANCING HALAL COMPLIANCE THROUGH ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING.....49

**Neira Fazlović, Faruk Čaklovica, Kenan Čaklovica**
HALAL STATUS OF UNCONVENTIONAL ANIMAL SPECIES AS A SOURCE OF HUMAN NUTRITION.....57

F

**JOURNAL**
**OF HALAL QUALITY AND CERTIFICATION**

# IN VITRO STUDY OF THE ANTIFUNGAL ACTIVITY OF 10% PROPOLIS EXTRACT IN PROPYLENE GLYCOL ON *CANDIDA ALBICANS*

**Zinka Hojkurić Rahmanović[1], Berin Rahmanović[2], Adnan Čučuković[3], Mirela Čučuković[3], Adnan Alijagić[2], Damir Alihodžić[4], Mehmed Sultanović[2], Munevera Begić[1]**

[1]Faculty of Agriculture and Food Science, University of Sarajevo, Zmaja od Bosne 8, 71000 Sarajevo, Bosnia and Herzegovina

[2]Faculty of Veterinary Medicine, University of Sarajevo, Zmaja od Bosne 90,71000 Sarajevo, Bosnia and Herzegovina

[3]OD "ECOMEDICO", Terezija bb, 71000 Sarajevo, Bosnia and Herzegovina

[4]Agency for Halal Quality Certification of Islamic Community in Bosnia and Herzegovina, Turalibegova 73, 75000 Tuzla, Bosnia and Herzegovina

*Corresponding author: Berin Rahmanović*
*E-mail address: berin.rahmanovic@vfs.unsa.ba*

*Original Scientific paper*

## ABSTRACT

Propolis is a bee product known for its pronounced biological and antimicrobial properties. Due to its complex chemical composition and the presence of numerous bioactive components, propolis is increasingly being tested as a potential natural agent for suppressing the growth of microorganisms, including fungi from the genus *Candida*. The aim of this work was to test the antifungal effect of 10% propolis extract in propylene glycol on *Candida albicans* in vitro, thereby contributing to the development of new natural therapeutic options in the fight against resistant fungal infections. The antimicrobial activity of the samples was tested using the growth inhibition test, which is one of the standard in vitro methods for assessing the sensitivity of microorganisms to antimicrobial substances. The observed zone of inhibition around the application site of the propolis extract indicates the sensitivity of *Candida albicans* to the action of propolis. The results indicate the antifungal potential of propolis extract and justify further research into its biological activity and possible application as a natural antimicrobial agent, while the use of propylene glycol as a carrier and solvent enables the formulation of preparations without ethyl alcohol, which means that this type of propolis can be considered suitable for the development of a functional halal product.

***Key words:*** *propolis, antifungal activity, Candida albicans*

## Introduction

*Candida* species are responsible for the majority of human infections caused by fungal pathogens (Lamoth et al., 2018). Species of *Candida* are present in as many as 400,000 systemic fungal diseases (Mukaremera et al., 2017).

Candida albicans is an opportunistic pathogenic fungus that is part of the normal human microflora, present on the mucous membranes of the oral cavity, gastrointestinal and urogenital tracts, as well as on the skin.

In physiological conditions, its growth is controlled by the immune system of the host and by competition from other microorganisms. However, by disrupting homeostasis, such as immunosuppression, antibiotic therapy or damage to the epithelial barrier, it enables the transition from commensal to pathogenic form and the development of infection (Lopes et al., 2022).

*Candida albicans* is the most common causative agent of mucosal infections and systemic infection, and it is responsible for about 70% of fungal infections around the world (Morad et al., 2018). *Candida albicans* colonizes the oral, gastrointestinal, and genital tracts asymptomatically (Bougnoux et al., 2006).

Clinical manifestations of *Candida albicans* infections include superficial candidiasis infections (cutaneous candidiasis, oropharyngeal candidiasis, and vulvovaginitis) that are frequent but usually benign in immunocompetent hosts. They also include severe infections in hospitalized patients, in particular, candidemia and disseminated candidiasis, that are associated with high mortality rates (Calderone, 2002).

Candidiasis serves as the overarching term for a spectrum of fungal infections caused by yeasts of the genus *Candida* and represents the most common fungal infection worldwide (Fan et al., 2023). Globally, an estimated 1.5 million people develop candidemia or invasive candidiasis annually (Denning et al., 2024).

One of the key roles of *Candida albicans* is its ability to morphologically transform between the yeast (blastospore), pseudohyphal and hyphal form. This dimorphic nature enables adaptation to different environmental conditions and is directly related to pathogenicity, because the hyphal form facilitates tissue invasion and avoidance of the host's immune response (Talapko et al., 2021).

The virulence of *Candida albicans* is based on several factors, including adhesion to host cells and abiotic surfaces, secretion of hydrolytic enzymes, and the ability to form biofilms (Henriques and Silva, 2021). Biofilm plays an extremely important role in the pathogenesis of infection because it increases resistance to atifugal drugs and the immune response of the host (Gulati and Nobile, 2016).

Contemporary research also points to the growing problem of antifungal resistance, especially in strains that have the ability to form biofilms. This phenomenon significantly complicates the therapeutic approach and reduces the effectiveness of existing antifungal drugs, which further emphasizes the need for the development of new antimicrobial agents, including natural bioactive substances (Amann et al., 2025).

Natural products of plant origin and synthetic chemistry represent the two main areas on which scientific attention is focused in order to develop effective antimicrobial agents for the treatment and prevention of infectious diseases (Anand et al., 2019).

Bee products have been used for treatment in folk medicine for centuries. Apitherapy is a type of alternative therapy that bee products are used that obtained directly from honeybees. Bee products such as honey, royal jelly, beeswax, bee venom, propolis, and pollen are thought to be beneficial to humans due to their biological and pharmacological properties (Albayrak, 2008).

In the Holy Quran, in Surah An-Nahl (The Bees) (16: 68-69), the importance of bees and their products is emphasized, stating: And your Lord inspired the bees: "Make ˹your˺ homes in the mountains, the trees, and in what people construct, and feed from ˹the flower of˺ any fruit ˹you please˺ and follow the ways your Lord has made easy for you." From their bellies comes forth liquid of varying colours, in which there is healing for people. Surely in this is a sign for those who reflect.

Propolis is a resinous and waxy substance collected by bees from the leaves, stems, buds, and similar parts of plants, which has a nice and pungent smell and does not dissolve in water. Propolis wax at 15−20°C, at 30−40°C sticky and gum-like. Generally, it melts at 60–70°C, when frozen times take a hard and brittle structure. Propolis gains a strong and sticky property due to the change of the structure of the collected plant resin by the bees (Silici, 2019).

The structure of propolis consists of 50% resin and herbal balm, 30% wax, 10% essential and aromatic oils, 5% pollen, 5% protein, and other substances (Przbylek and Karpinski, 2019). There are more than 300 compounds in the content of propolis. These are polyphenols

(flavonoids, phenolic acid, and its esters), terpenoids, steroids, aromatic acid, and its esters, alcohols, aldehydes, chalcones, hydrocarbons, quinones, amino acids, coumarin, ketones, essential fatty acids, vitamins (B1, B2, B6, A, C, and E), and minerals (calcium, magnesium, potassium, sodium, manganese, selenium, iron, zinc, and copper). Polyphenols and terpenoids are considered the most active compounds. Propolis supports the immune system with its antimicrobial, anti-inflammatory, and antioxidant properties (AL-Ani at al., 2018).

Compounds such as flavonoids and phenolic compounds present in honey and propolis are responsible for their antifungal activity affecting the permeability of the cytoplasmic membrane and resulting in the complete release of cellular components and inorganic ions, which leads to complete cell death (Shehu et al., 2016). The antifungal effect of flavonols such as kaempferol, quercetin, and myricetin has been defined to inhibit the growth and cell division of *Candida albicans* (Herrera et al., 2010).

Because of a lot of impurities and insolubility in water, raw propolis cannot be used directly in food products and must be extracted to separate of active ingredients (Bankova et al., 2021). Propolis extracts can be prepared using different solvents, including ethanol, water and propylene glycol, where the choice of solvent significantly affects the chemical composition and biological activity of the extract (Šuran et al., 2021, Milek et al., 2024).

Propylene glycol is an alternative solvent that enables formulation without the presence of ethyl alcohol, while retaining a significant part of the bioactive components and antioxidant potential of propolis (Liaudanskas et al., 2021).

**Subject and problem of research**

The subject of this research is testing the antifungal activity of the alcohol-free extract of propolis, formulated in propylene glycol, on the growth and development of the fungus *Candida albicans* in laboratory (in vitro) conditions.

The growing resistance of the fungus *Candida albicans* to conventional antifungal drugs represents a significant public health problem, especially considering the high mortality rate in systemic candidiasis. This phenomenon indicates the need to find new, efficient and safe therapeutic alternatives. In this context, natural products, such as propolis, especially in alcohol-free formulations suitable for wider use (for example for the halal industry), represent a potential source of antifungal agents. Therefore, the research problem relates to determining the extent to which non-alcoholic extract of propolis, dissolved in propylene glycol, can inhibit the growth of *Candida albicans.*

**The aim of the research**

The aim of this research is to examine the antifungal effect of propolis extract, formulated in 10% propylene glycol, on the growth of *Candida albicans* in in vitro conditions, and to assess its potential as a natural alternative to conventional antifungal drugs in the context of growing antimicrobial resistance.

**Material and methods**

For the research in this work, native propolis collected from the area of northern Bosnia in August 2025 was used. After collection, the material was cleaned of mechanical impurities and stored in a dark and dry place until use. Pharmaceutical grade propylene glycol (FCC grade) was used to prepare the extract. The tested microorganism was the reference strain *Candida albicans.*

**Preparation of propolis solution in propylene glycol**

The raw propolis was previously ground to fine particles to increase the contact surface and more efficient extraction of bioactive components. An accurately measured mass of propolis was transferred to an appropriate glass container, after which pharmaceutical grade propylene glycol was added, thus preparing a 10% (w/v) solution.

The resulting mixture was homogenized and then stored in dark conditions, protected from direct light, at room temperature. The extraction process lasted 21 days, with daily stirring to enable optimal diffusion and dissolution of the bioactive components of propolis in the solvent. After the extraction was completed, the solution

was filtered through sterile filter paper to remove undissolved particles. The extract prepared in this way was stored in dark glass vials until further use.

Antimicrobial (antifungal) activity testing was conducted in three independent experiments, with each sample analyzed in 5 parallel replicates.

Nystatin (the most commonly used antifungal drug due to its reliable and standardized activity) was used as a positive control, while propylene glycol was used as a negative control. The tested sample was a 10% propolis extract formulated in propylene glycol.

The antimicrobial activity of the samples was tested using the growth inhibition test, which is one of the standard in vitro methods for assessing the sensitivity of microorganisms to antimicrobial substances. For this purpose, the agar well diffusion method was used, which is widely used to assess the antimicrobial activity of plants or microbial extracts. The procedure is based on a principle similar to the disk diffusion method, where the surface of the agar plate is inoculated by evenly spreading the volume of microbial inoculum (*Candida albicans*) over the entire surface of the nutrient medium. After inoculation, a hole with a diameter of 6 to 8 mm is aseptically drilled in the agar, using a sterile cork drill or a suitable instrument. A defined volume (100 μL) of the tested antimicrobial is added to the well (in this case; positive control-Nystatin, negative control propylene glycol, tested sample 10% propolis extract formulated in propylene glycol). The plates are then incubated at 25°C for 24 hours.

The activity of the tested antimicrobial (antifungal) agents was assessed by visual observation of the zone of inhibition, i.e. the area around the site of application of the preparation in which the absence or reduction of *Candida albicans* growth was observed. Antimicrobial activity was additionally quantified by measuring the diameter of the formed zones of inhibition. The diameter of the zone of inhibition was measured in two mutually perpendicular directions, and their average was taken as the final value. The results are presented as the mean value.

**Results**

By visual observation, zones of growth inhibition were observed around the site of application of antimicrobial (antifungal) agents, including 10% propolis extract in propylene glycol, Nystatin as a positive control, and propylene glycol as a negative control. The presence of these zones indicates the inhibition of the growth of *Candida albicans* in the immediate vicinity of the application site of the mentioned preparations. The obtained results are shown in Figure 1.

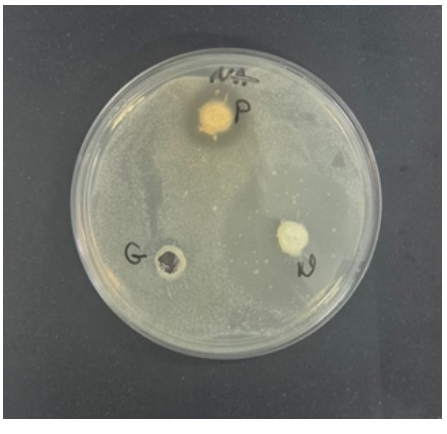


Figure 1. Zone of growth inhibition of the tested microorganism *Candida albicans* in the presence of tested substances: P - propolis, G - propylene glycol, N – Nystatin

Antimicrobial (antifungal) activity was additionally quantified by measuring the diameter of the formed inhibition zones. The diameter of the inhibition zone was measured in two mutually perpendicular directions, and their average was taken as the final value. The results are shown in Table 1.

The experiment of testing antifungal activity on *Candida albicans* culture, using the diffusion method in agar wells, was carried out through three independent trials, where each sample was analyzed in five parallel repetitions, which enables the reliability and reproducibility of the obtained results. Nystatin was used as a positive control, while propylene glycol was used as a negative control. The tested sample was a 10% propolis extract formulated in propylene glycol.

Table 1. Antifungal activity against Candida albicans

| Treatment | Number of samples (n) | Minimum (mm) | Maximum (mm) | Mean value (mm) |
|---|---|---|---|---|
| 10% propolis extract in propylene glycol | 15 | 4.0 | 8.0 | 6.0 |
| Nystatin (positive control) | 15 | 12.0 | 18.0 | 15.0 |
| Propylene glycol (negative control) | 15 | 0.0 | 0.0. | 0.0. |

The research results shown in Table 1. show that the positive control (Nystatin) achieved the highest antifungal activity, with an average diameter of the zone of inhibition of 15.0 mm for *Candida albicans*. The tested sample, 10% propolis extract in propylene glycol, also showed antifungal activity, with the average diameter of inhibition being 6.0 mm. Unlike the mentioned samples, the negative control (propylene glycol) did not show the presence of an inhibition zone, which indicates the absence of antifungal activity of the solvent itself. The obtained result confirms that 10% propolis extract has antifungal activity against *Candida albicans*, although it is less pronounced compared to the standard antifungal drug Nystatin.

**Discussion**

Contemporary research indicates an increasingly pronounced trend towards the use of natural bioactive substances in the therapy of fungal infections, as an alternative to conventional synthetic drugs. This approach is based on the need to reduce side effects, toxicity and the emergence of resistance, which are often associated with the long-term use of antifungal drugs (Silva-Beltrán et al., 2023). The growing rate of resistance of the *Candida* fungus to conventional pharmacological drugs is an increasingly important focus of modern medicine, especially considering the high mortality rate associated with systemic candidiasis. This situation clearly indicates the need for the urgent development of alternative medicines, whereby special attention is directed to potential natural ingredients such as propolis (Maheswari Soerjanto et al., 2023).

Taking into account the above, the subject research is aimed at testing the antifungal effect of non-alcoholic propolis extract formulated in propylene glycol on *Candida albicans* in vitro conditions, with a parallel comparison of its effectiveness with the standard antifungal drug Nystatin as a positive control. The obtained results indicate that a 10% extract of alcohol-free propolis in propylene glycol achieves an inhibitory effect on the growth of the *Candida albicans* fungus, which was confirmed by the formation of an inhibition zone of 6.0 mm. In contrast, the positive control (Nystatin) showed significantly more pronounced antifungal activity with higher mean values of the zone of inhibition of 15.0 mm, which confirms its standardized efficiency. In the case of the negative control (propylene glycol), no zone of inhibition was recorded, thus confirming that the carrier itself has no antifungal activity.

The formation of an action zone on the nutrient medium is clear evidence of the diffusion of bioactive components of propolis through the agar, where the growth of microorganisms is inhibited. The antifungal activity of propolis is most often associated with the presence of flavonoids, phenolic acids and other bioactive compounds that can damage the integrity of the cell membrane, interfere with metabolic processes, slow down growth or lead to the death of fungal cells.

These findings confirm the potential of non-alcoholic propolis extract as a natural antifungal agent, although its activity is weaker compared to standard antifungal medicine, which indicates the need for further research in order to optimize the concentration, formulation and method of administration.

The obtained results of this research are in accordance with the findings of other authors, who confirmed the antifungal effect of propolis on various species of the genus *Candida*, including *Candida albicans*. In the available literature, it is stated that propolis, regardless of its geographical origin and method of extraction, shows the ability to inhibit the growth and

development of fungi, which is confirmed by the research results in the following studies.

In a study by Babić et al. (2011), it was confirmed that propolis originating from Bosnia and Herzegovina has a pronounced antifungal effect on *Candida albicans*. The obtained results indicate that the intensity of the inhibitory effect depends on the concentration of the extract, whereby the 30% ethanol extract of propolis showed the most pronounced antifungal activity. Namely, using the disk diffusion method, average inhibition zones of 7.56 mm were recorded for *Candida albicans*.

In the study by Özkök et al. (2021), propolis extracts prepared using different solvents and concentrations were analyzed, whereby propolis samples originating from different geographical regions were dissolved in ethanol and propylene glycol. In this research, the 15% extract in propylene glycol shows statistically similar results to the 20% ethanol extract, which indicates that propylene glycol is an efficient alternative solvent while preserving the antioxidant potential.

An ethanolic extract of Turkish propolis showed the highest antifungal activity against 76 candida isolates (*C. albicans*, *C. parapsilosis*, *C. tropicalis*, and *C. glabrata*) that were isolated from the blood cultures of intensive care unit patients, with an MIC range of 0.185 to 3 μg/mL (Mutlu Sariguzel et al., 2016). Most likely, extraction method affects the activity of propolis: an ethanolic extract of French poplar-type propolis showed considerable activity against *C. albicans* at an MIC equal to 31.25 μg/mL (Boisard et al., 2015).

A review of the literature in the study by Maheswari Soerjanto et al. (2023) shows that propolis has antifungal activity against *Candida albicans*, confirmed by low values of the minimum inhibitory concentration of 0.06 μg/mL and the minimum fungicidal concentration of 0.121 μg/mL. Despite the differences in the methods of extraction and testing, all analyzed papers confirm its ability to inhibit growth and fungicidal action, which indicates the potential of propolis as a natural non-pharmacological therapy for fungal infections.

In the Qur'an, in Sura En-Nahl (Bees) (16: 68 – 69), the importance of bees and their products is emphasized, where it is stated that from their entrails comes out a drink of different colors that is a medicine for people, which indicates the potential biological and therapeutic value of bee products. In this context, modern scientific research confirms that a bee product like propolis has significant antimicrobial (antifungal) properties. Propolis, as a complex resinous substance rich in flavonoids and phenolic compounds, shows pronounced antifungal activity, including inhibition of *Candida albicans* growth. These findings enable the integration of traditional religious sources and modern scientific evidence, which further confirms the importance of propolis extract as a natural bioactive agent with potential application in medicine and the food industry.

## Conclusion

Considering the importance of *Candida albicans* as an opportunistic pathogen and the increasing need for testing natural antimicrobial (antifungal) agents, propolis, as a natural product of bees, rich in flavonoids and phenolic compounds, shows pronounced antifungal activity against *Candida albicans*, which is confirmed by the results of in vitro research. The research results indicate that propolis extract, prepared with the use of 10% propylene glycol as a carrier, retains significant antifungal activity against *Candida albicans*. The obtained data confirm the significant antifungal potential of propolis and justify its further application and research under controlled conditions. In this context, the Qur'anic statement from Surah En-Nahl (Bees) (16: 68 – 69) that in bee products "there is medicine for humans" can be interpreted in the light of modern scientific knowledge, where propolis is recognized as a natural antimicrobial agent. Therefore, propolis represents a promising natural alternative or supplement to conventional therapeutic approaches. Additionally, the elimination of ethyl alcohol from the formulation enables its application in accordance with halal principles, which opens up the possibility of developing functional and natural products for the halal market. This approach represents an important combination of traditional natural resources and contemporary requirements of the halal industry.

**Reference**


AL-Ani I, Zimmermann S, Reichling J, Wink M. (2018): Antimicrobial activities of European propolis collected from various geographic origins alone and in combination with antibiotics. Medicine. 2018;5 (2):1-17

Albayrak S., (2008): Propolis: Natural antimicrobial matter. Ankara Üniversitesi Eczacılık Fakültesi Dergisi. 2008;37 (3):201-215

Amann Valerie, Kissmann Ann-Kathrin, Firacative Carolina and Frank Rosenau (2025): Biofilm-Associated Candidiasis: Pathogenesis, Prevalence, Challenges and Therapeutic Options, Pharmaceuticals 2025, 18(4), 460; https://doi.org/10.3390/ph18040460

Anand U., Jacobo-Herrera N., Altemimi A., Lakhssassi N., (2019): A Comprehensive review on medicinal plants as antimicrobial therapeutics: potential avenues of biocompatible drug discovery, Metabolites, 9 p. 258, 10.3390/metabo9110258

Babić Senka, Pašić Š., Dukić Behija, Čoralić Agnesa (2011): Antifungal activity of propolis originated from Bosnia and Herzegovina, Veterinaria 60 (3-4), 187-193

Bankova V., Trusheva B., Popova M. (2021): Propolis extraction methods: a review. J Apic Res 60:734–743.

Boisard S., Le Ray A.M., Landreau A., Kempf M., Cassisa V., Flurin C., Richomme P. (2015): Antifungal and antibacterial metabolites from a French poplar type propolis, Evidence-Based Complementary and Alternative Medicine, 2015 pp.

Bougnoux ME, Diogo D., Francois N., Sendid B., Veirmeire S., Colombel J.F., Bouchier C., Van Kruiningen H., d'Enfert C., Poulain D. (2006): Multilocus sequence typing reveals intrafamilial transmission and microevolutions of Candida albicans isolates from the human digestive tract. J Clin Microbiol. 2006 May;44 (5):1810–1820.

Calderone R. (2002): Taxonomy and biology of *Candida*, p. 15-29. *In* R. Calderone (ed.), *Candida and candidiasis*. ASM Press, Washington, D.C.

Denning DW. (2024): Global incidence and mortality of severe fungal disease. Lancet Infect Dis. 2024 Jul;24(7):e428-e438.

Fan Y, Wu L, Zhai B. (2023): The mycobiome: interactions with host and implications in diseases. Curr Opin Microbiol. 2023 Oct;75:102361.

Gulati Megha and Nobile Clarissa J. (2016): Candida albicans biofilms: development, regulation, and molecular mechanisms, Microbes and Infection Volume 18, Issue 5, May 2016, Pages 310-321

Henriques Mariana and Silva Sónia (2021): *Candida Albicans* Virulence Factors and Its Pathogenicity, Microorganisms 2021, 9(4), 704

Herrera CI., Alvear M., Barrientos I., Montenegro G., Salazar IA. (2010): The antifungal effect of six commerical extracts of Chilean propolis on Candida spp. Ciencia e Investigación Agraria.; 37:75-84

Quran. Translation of the meanings: Besim Korkut. Sarajevo: El-Kalem; 2001

Lamoth F., Lockhart SR., Berkow EL., Calandra T. (2018): Changes in the epidemiological landscape of invasive candidiasis. J Antimicrob Chemother. Jan 1;73(suppl_1):i4-i13. doi: 10.1093/jac/dkx444.

Liaudanskas Mindaugas, Kubilienė Loreta, Žvikas Vaidotas, Trumbeckaitė Sonata (2021): Comparison of Ethanolic and Aqueous-Polyethylenglycolic Propolis Extracts: Chemical Composition and Antioxidant Properties, Evid Based Complement Alternat Med. 2021 Mar 17; 1:5557667.

Lopes José Pedro and Lionakis Michail S. (2022): Pathogenesis and virulence of Candida albicans, Virulence, Volume 13, 2022 - Issue 1

Maheswari Soerjanto Olivia, Endraswari Pepy Dwi, Rizki Purba Abdul Khairul (2023): Antifungal Potential of Propolis Extract Against Candida Albicans: Literature Review | International Journal of Science and Society, International Journal of Science and Society (IJSOC) / Vol 5 No 5

Miłek Michał, Bonikowski Radosław and Dżugan Małgorzata (2024):The effect of extraction conditions on the chemical profile of obtained raw poplar propolis extract, Original Paper, Open access, Published: 18 June 2024, Volume 78, pages 6709–6720

Morad H.O.J., Wild A.-M., Wiehr S., Davies G., Maurer A., Pichler B.J., Thornton C.R. (2018): Pre-clinical Imaging of Invasive Candidiasis Using ImmunoPET/MR. Front. Microbiol. 2018;9:1996. doi: 10.3389/fmicb.2018.01996.

Mukaremera L., Lee K.K., Mora-Montes H.M., Gow N.A.R. (2017): *Candida albicans* yeast, pseudohyphal, and hyphal morphogenesis differentially affects immune recognition. Front. Immunol. 2017;8:1. doi: 10.3389/fimmu.2017.00629.

Mutlu Sariguzel F., Berk E., Koc A.N., Sav H., Demir G. (2016): Antifungal activity of propolis against yeasts isolated from blood culture: In vitro evaluation, Journal of Clinical Laboratory Analysis, 30 (5) pp. 513-516

Özkök Aslı, Keskin Merve, Tanuğur Samancı Aslı Elif, Yorulmaz Önder Elif, Takma Çiğdem (2021): Characterization of Propolis Extracts Prepared Using Different Solvents at the Different Concentrations, Progress in Nutrition 2021; Vol. 23, N. 3.

Przbylek I., and Karpinski TM. (2019): Antibacterial properties of propolis. Molecules. 2019;24:2047.

Shehu A., Ismail S., Rohin MAK, Harun A., Aziz AA., Haque M. (2016): Antifungal properties of

Malaysian tualang honey and stingless bee propolis against *Candida albicans* and *Cryptococcus neoformans*. Journal of Applied Pharmaceutical Science. 2016;6(2):44-50
Silici S. (2019): Honeybee products and therapy. Turkish Journal of Agriculture-Food and Science Technology (TURJAF). 2019;7(9):1249-1262
Silva-Beltrán Norma Patricia, Boon Stephanie A., Khalid Ijaz M., McKinney Julie, Charles P. (2023): Gerba Antifungal activity and mechanism of action of natural product derivates as potential environmental disinfectants, Journal of Industrial Microbiology and Biotechnology, Volume 50, Issue 1, 2023, kuad036,
Šuran Jelena, Cepanec Ivica, Mašek Tomislav, Radić Božo, Radić Saša, Tlak Ivana Gajger, Vlainić Josipa (2021): Propolis Extract and Its Bioactive Compounds—From Traditional to Modern Extraction Technologies, Molecules. 2021 May 14;26(10):2930.
Talapko Jasminka, Juzbašić Martina, Matijević Tatjana, Pustijanac Emina, Bekić Sanja, Kotris Ivan and Škrlec Ivana (2021): *Candida albicans*—The Virulence Factors and Clinical Manifestations of Infection, J. Fungi 2021, 7(2), 79

# IN VITRO ISPITIVANJE ANTIFUNGALNOG DJELOVANJA 10% EKSTRAKTA PROPOLISA U PROPILEN GLIKOLU NA CANDIDA ALBICANS

**Zinka Hojkurić Rahmanović[1], Berin Rahmanović[2], Adnan Čučuković[3], Mirela Čučuković[3], Adnan Alijagić[2], Damir Alihodžić[4], Mehmed Sultanović[2], Munevera Begić[1]**

[1]Poljoprivredno-prehrambeni fakultet, Univerzitet u Sarajevu, Zmaja od Bosne 8, 71000 Sarajevo, Bosna i Hercegovina
[2]Veterinarski fakultet, Univerzitet u Sarajevu, Zmaja od Bosne 90, 71000 Sarajevo, Bosna i Hercegovina
[3]OD "ECOMEDICO", Terezija bb, 71000 Sarajevo, Bosna i Hercegovina
[4]Agencija za certificiranje halal kvalitete Islamske zajednice u Bosni i Hercegovini, Turalibegova 73, 75000 Tuzla, Bosna i Hercegovina

*Autor za korespodenciju: Berin Rahmanović*
*E-mail address: berin.rahmanovic@vfs.unsa.ba*

## SAŽETAK

Propolis je pčelinji proizvod poznat po izraženim biološkim i antimikrobnim svojstvima. Zbog složenog hemijskog sastava i prisustva brojnih bioaktivnih komponenti, propolis se sve češće ispituje kao potencijalno prirodno sredstvo za suzbijanje rasta mikroorganizama, uključujući gljivice iz roda *Candida*. Cilj ovog rada bio je ispitati antifungalno djelovanje ekstrakta 10% propolisa u propilen glikolu na *Candida albicans* u *in vitro* uslovima, čime se doprinosi razvoju novih prirodnih terapijskih opcija u borbi protiv rezistentnih gljivičnih infekcija. Antimikrobna aktivnost uzoraka ispitana je primjenom testa inhibicije rasta, koji predstavlja jednu od standardnih in vitro metoda za procjenu osjetljivosti mikroorganizama na antimikrobne supstance. Uočena zona inhibicije oko mjesta aplikacije ekstrakta propolisa ukazuje na osjetljivost *Candida albicans* na djelovanje propolisa. Rezultati ukazuju na antifungalni potencijal ekstrakta propolisa i opravdavaju dalja istraživanja njegove biološke aktivnosti i moguće primjene kao prirodnog antimikrobnog sredstva, dok primjena propilen glikola kao nosača i rastvarača omogućava formulaciju preparata bez etilnog alkohola, čime se ovakav propolis može smatrati pogodnim za razvoj funkcionalnog halal proizvoda.

**Ključne riječi:** *propolis, antifungalno djelovanje, Candida albicans*

**JOURNAL
OF HALAL QUALITY AND CERTIFICATION**

# STRATEGIC FINANCIAL MANAGEMENT IN THE FUNCTION OF LONG-TERM SUSTAINABLE DEVELOPMENT OF THE HALAL INDUSTRY IN THE CONTEXT OF DIGITALIZATION AND ARTIFICIAL INTELLIGENCE

**Ismet Kalić**

University FINRA Tuzla, Mitra Trifunovića Uče 9, 75000 Tuzla, Bosnia and Herzegovina

*Corresponding author: Ismet Kalić*
*E-mail address: ismet.kalic2020@gmail.com*

*Review paper*

## ABSTRACT

The halal industry is recognized as one of the fastest-growing global sectors, with significant and continuously expanding market value. Its sustainable development requires not only compliance with religious and ethical standards but also the application of modern strategic financial management tools capable of responding to the challenges of a dynamic business environment. This paper analyzes the role of strategic financial management in ensuring the long-term sustainable development of the halal industry, with particular emphasis on the transformative potential of digitalization and artificial intelligence (AI).

The paper is based on an analysis of relevant scientific and professional literature, a review of global halal market trends, and a comparative examination of existing theoretical and empirical knowledge in the fields of strategic financial management and the halal industry. The paper explores how AI-powered tools, such as predictive analytics, automated financial reporting, and intelligent risk management systems, are reshaping strategic financial decision-making within the halal sector.

The integration of artificial intelligence and digital technologies into strategic financial management processes is recognized as a key factor in enhancing the efficiency, transparency, and long-term sustainability of halal enterprises. The paper also examines the relationship between halal principles and ESG criteria (environmental, social, and governance) in the context of sustainable finance.

The paper indicates that the synergy of strategic financial management, digitalization and artificial intelligence represents a prerequisite for the long-term competitiveness and sustainability of the halal industry in the global environment. Such an approach enables the halal industry to respond to the challenges of the modern global market while preserving its core values.

**Keywords:** *halal industry, strategic financial management, digitalization, artificial intelligence, sustainable development*

## Introduction

The halal industry has recorded strong growth over the past decades, positioning itself as a strategically important segment of the global economy. The global halal economy was valued at USD 7.36 trillion in 2023, with projections indicating growth to USD 10.89 trillion by 2028 (SESRIC, 2025). The halal food sector alone recorded a value of USD 1.97 trillion in 2025, with expected growth to USD 2.24 trillion in 2026 at an annual growth rate of 13.4%, while

by 2030 it is projected to reach USD 3.66 trillion (Research and Markets, 2026).

The long-term sustainable development of the halal industry requires not only compliance with religious and ethical standards, but also the application of modern strategic financial management tools capable of responding to the challenges of a dynamic business environment. The Fourth Industrial Revolution, characterized by rapid technological advancement and an increasing focus on automation, necessitates the continuous introduction of digital innovations in order for companies to enhance their market competitiveness (Kalić I., Ćatić N. and Ćatić T., 2025). For the halal industry, this necessity is particularly significant given the complexity of maintaining certification compliance, halal supply chain integrity, and cross-border financial management across multiple regulatory jurisdictions (Firmansyah et al., 2025).
At the same time, the growing alignment between halal principles and ESG criteria is opening new opportunities for sustainable financing within the halal sector. The purpose of this paper is to analyze the role of strategic financial management in ensuring the long-term sustainable development of the halal industry, with particular emphasis on the transformative potential of digitalization and artificial intelligence.

## Materials and Methods

This paper is based on a systematic review and analysis of relevant scientific and professional literature in the fields of strategic financial management, digitalization, artificial intelligence, and the halal industry. The research methodology encompasses a comparative analysis of existing theoretical and empirical knowledge, a review of global halal market reports and statistical data, and an examination of current trends in the application of digital technologies in financial management. Primary data sources include reports by SESRIC, Research and Markets, McKinsey & Company, IBM, and Gartner, as well as peer-reviewed scientific publications.
The paper applies a descriptive-analytical and synthetic approach in order to integrate findings from multiple disciplines into a coherent theoretical framework.

## Results and Discussion

### 1. Financial Aspects of the Halal Industry and the role of Strategic Financial Management

The halal industry has evolved from a niche market into a mainstream global industry. The global halal economy was valued at USD 7.36 trillion in 2023, with projections indicating growth to USD 10.89 trillion by 2028, driven by demographic expansion, rising incomes, digitalization, and growing demand for ethical and sustainable products (SESRIC, 2025). The halal food sector alone recorded a value of USD 1.97 trillion in 2025, with expected growth to USD 2.24 trillion in 2026 at an annual growth rate of 13.4%, while by 2030 it is projected to reach USD 3.66 trillion (Research and Markets, 2026). Global Islamic finance assets reached approximately USD 6 trillion in 2024, with around 95% concentrated in OIC[1] member countries (SESRIC, 2025). In Muslim-majority countries such as Malaysia, Indonesia, and the UAE, the halal industry contributes more than 7% to national GDP (Noviyanti & Hakim, 2025). With more than 80% of global halal consumption concentrated in OIC countries, the sector holds significant strategic importance for economic diversification, trade integration, and employment generation (SESRIC, 2025).

Halal enterprises face specific financial challenges that distinguish them from conventional businesses. Despite certification and adherence to Islamic principles, many halal enterprises struggle with optimizing financial performance, indicating that certification alone is insufficient for success (Siregar et al., 2025). The halal supply chain encompasses not only the procurement of halal-certified raw materials, but also all handling, storage, packaging, distribution, and marketing processes, which must be aligned with halal principles (Firmansyah

1 OIC – Organisation of Islamic Cooperation, an international organization founded in 1969 comprising 57 member states, established with the aim of strengthening political, economic, and cultural cooperation among Muslim countries and protecting the common interests of the Islamic world.

et al., 2025). Despite its rapid growth, the halal industry continues to face structural challenges, including fragmented regulatory frameworks, inconsistent certification systems, limited technology adoption, and restricted access to halal-compliant financing (SESRIC, 2025).

Strategic financial management in the halal sector encompasses three key activities: financial planning and budgeting, investment decisions, and financing decisions (Silvira, Rofi'ah, Utami and Endang, 2023). Without precise and realistic planning, it is difficult to make sound investment and financing decisions (Kalić, 2017). Investment decisions have a long-term impact on a company's cash flows, and errors in investment decisions cannot be corrected in the short term without incurring significant costs (Rovčanin, 2006). Financing decisions in halal enterprises require alignment between Islamic financing instruments and the practical requirements of business finance. This implies that halal enterprises must select sources of financing that are consistent with Sharia principles while simultaneously being sufficiently efficient, accessible, and cost-effective to meet the day-to-day operational and developmental needs of the business.

The digitalization of financial processes provides real-time financial information, enabling companies to be more adaptive, responsive, and proactive in their operations (Ahmad, 2024). Blockchain technology has been applied to record the complete journey of a product from raw material sourcing to the end consumer in a transparent and tamper-proof manner (Firmansyah et al., 2025). According to McKinsey & Company (2025), 78% of global companies use artificial intelligence to improve and optimize their operations, a trend that is increasingly reflected in the halal sector as well.

## 2. Artificial Intelligence as a Tool of Strategic Financial Management in the Halal Industry

Artificial intelligence is assuming an increasingly significant role as a strategic instrument of financial management, transforming the way halal enterprises plan, report, and manage risks. Machine learning algorithms are capable of analyzing vast quantities of financial and alternative data, identifying patterns, and supporting more informed financial decision-making (Kalić I., Ćatić N. and Ćatić T., 2025). Predictive analytics represents one of the most impressive applications of artificial intelligence in strategic financial management. A 2024 IBM report demonstrated that companies which implemented artificial intelligence for cash flow forecasting reduced errors and increased accuracy by up to 95%.

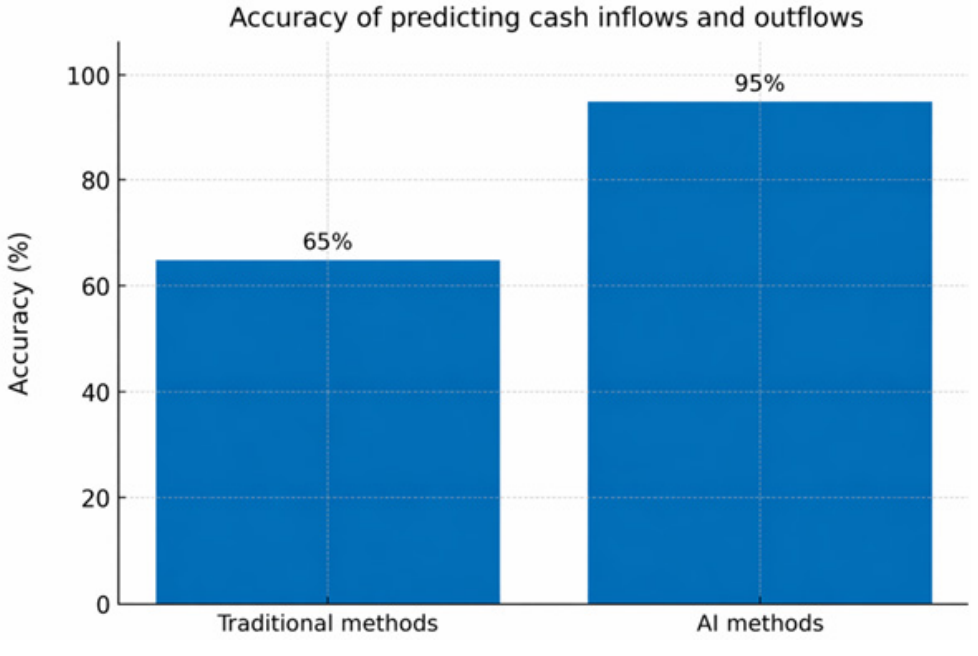


Figure 1. Traditional vs. AI-powered cash flow forecasting

Source: Phoenix Strategy Group (2026). Retrieved from: https://www.phoenixstrategy.group/blog/how-ai-predictive-analytics-improves-cash-flow-forecasting (accessed 18 April 2026).

For halal enterprises, predictive analytics can integrate data from multiple sources, including historical sales data, religious events, demographic trends in key markets, and price movements of halal-certified raw materials. Improved synchronization of cash inflows and outflows is achieved through the use of artificial intelligence in optimizing invoicing, collections, and payments, thereby shortening the time required to convert receivables into cash and optimizing the cash conversion cycle (Kalić I., Ćatić N. and Ćatić T., 2025). Real-time insights reduce financial risk by mitigating the danger of payment deadline breaches, missed payments, or defaults on obligations (Kalić I., Ćatić N. and Ćatić T., 2025). The application of artificial intelligence in the halal industry, while not yet having reached the level of maturity present in large global corporations, is gradually gaining significance through the practices of Islamic financial institutions and companies operating in the halal segment. Research indicates that AI enhances efficiency, decision-making, and risk management in Islamic banks, enabling more precise financial planning and forecasting (Ahmed & Traore, 2026).

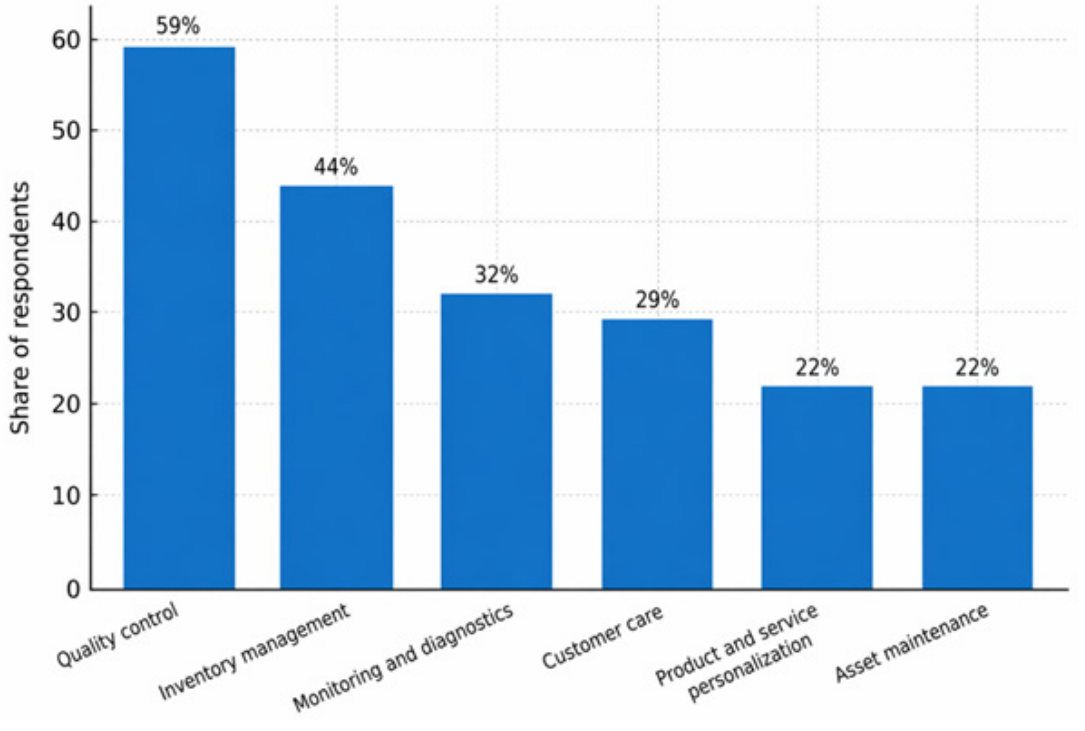


Figure 2. Business areas in which AI software is most commonly applied

*Source: Liquid Web (2026). Retrieved from: https://www.liquidweb.com/blog/ai-inventory-management/ (accessed 19 April 2026.)*

The chart shows that quality control holds the leading position among business areas for the application of artificial intelligence, which is of particular significance for halal enterprises, given that continuous monitoring and verification of compliance with halal standards represent a fundamental operational requirement at all stages of the production process. Inventory management stands out as another key area of AI implementation. Nevertheless, artificial intelligence is not in a position to fully replace the human factor, particularly when it comes to complex strategic decisions that require foresight, adaptability, and creativity.

Automated financial reporting plays a significant role in the halal industry, where documentation and transparency requirements are further heightened due to complex regulatory frameworks, the need for Sharia compliance, and the preservation of halal standards integrity. AI

tools in the field of financial reporting automate data entry, generate financial statements, and enable insight into financial performance in real time (Kalić I., Ćatić N. and Ćatić T., 2025). For halal enterprises, this approach is of particular importance as halal certification bodies and regulatory authorities require detailed and continuous documentation on supply chain compliance, raw material procurement, and production processes. AI systems enable the automated collection, processing, and compilation of this data, thereby significantly reducing the administrative burden and costs of maintaining halal certification across different jurisdictions (Noviyanti & Hakim, 2025).

Intelligent AI-based risk management systems represent an important tool of strategic financial management in the halal industry, as they enable timely identification, assessment, and mitigation of financial and operational risks. The operations of halal enterprises are burdened by specific risks, including the possibility of cross-contamination between halal and non-halal products, certification-related risks, as well as operational and financial risks in production planning and supply chain management (Firmansyah et al., 2025). In this context, AI systems enable continuous monitoring of supplier compliance, predictive analysis of potential disruptions, and cost optimization, thereby directly contributing to higher-quality investment and financial decision-making. In practice, the application of these technologies is evident in the halal industry, particularly in developed markets such as Malaysia and Indonesia, where digital platforms and blockchain are used to enhance the tracking and verification of the halal status of products (Noviyanti & Hakim, 2025). Additionally, in the Islamic financial sector, AI systems are used to monitor financial transactions and manage investment portfolios in accordance with Sharia principles, thereby reducing regulatory and reputational risks and enhancing the long-term sustainability of operations. Although the effectiveness of these systems depends on data quality, their integration into business processes enables halal enterprises to improve strategic planning, increase transparency, and make more informed financial decisions, thus confirming the role of artificial intelligence as a key tool of strategic financial management in the halal industry.

## Halal Principles, Esg and Long-Term Sustainable Development

Halal principles and ESG criteria share the same fundamental values of ethical business conduct, social responsibility, and long-term sustainability. This integration is increasingly referred to by the term "Halal-ESG", which implies a broader approach than mere regulatory compliance, encompassing ethical sourcing, responsible environmental management, protection of labour rights, and transparent corporate governance.

From an environmental protection perspective, the halal industry emphasises the use of sustainable sources, eco-friendly packaging, and the reduction of CO2 emissions in the food, pharmaceutical, and cosmetics sectors (Iqbal, Javed & Bibi, 2025). The halal supply chain requires strict oversight at every stage from raw material to end consumer, thereby establishing transparency and accountability as fundamental values of ESG governance criteria (Firmansyah et al., 2025). Halal certification verifies not only the production process, but also logistical and distribution systems, which creates a natural alignment with ESG requirements for transparency and accountability in reporting (Firmansyah et al., 2025). The social dimension of ESG corresponds to halal principles of justice and social responsibility, and transparency in the supply chain, protection of labour rights, and ethical aspects as a foundation of consumer trust are directly aligned with ESG social criteria (Iqbal, Javed & Bibi, 2025).

The halal industry faces significant challenges in realising the potential of sustainable finance. SESRIC (2025) identifies fragmented regulatory frameworks, inconsistent certification and accreditation systems, limited technology adoption, and limited access to halal-compliant financing as key structural challenges. Different jurisdictions apply different halal standards, different Sharia interpretations, and different ESG reporting requirements (Noviyanti & Hakim, 2025). Furthermore, ESG remains primarily focused on developed countries with advanced

technologies, stable economies, and adequate infrastructure, which creates additional barriers for halal enterprises in developing countries (Wardah, 2025). Successful implementation of ESG principles in the halal industry requires collaborative engagement involving government institutions, the private sector, and consumers (Wardah, 2025). The transition to sustainable business models requires not only financial investment, but also knowledge transfer and training, and may take an extended period for effective implementation. Circularity as a long-term corporate strategy can significantly strengthen the financial position of enterprises, and the adoption of circular economy principles as the main philosophy for strategic planning provides companies with more stable cost control and increases market competitiveness (Kalić, Ćatić N. and Ćatić T., 2025). In this process, technology plays an indispensable role — Gartner predicts that by 2028, 50% of organisations will use artificial intelligence for data analysis and forecast generation (Gartner, 2024).

The growing market for green sukuk — Islamic bonds whose proceeds are designated for environmentally beneficial projects — represents a concrete example of the alignment of Islamic finance and ESG principles in the context of sustainable financing, with total issuances exceeding USD 20 billion by 2023 (Islamic Finance Development Report, 2023). Growing global awareness of ESG principles, technological innovations in financial management, and the expansion of Islamic finance infrastructure — with global Islamic finance assets reaching USD 6 trillion in 2024 (SESRIC, 2025) — are creating a favourable environment for the development of innovative sustainable financing solutions tailored to the specific needs of the halal industry. The integration of ESG principles with halal values and the application of modern digital technologies positions the halal industry as a model of ethical and sustainable global business. This approach not only contributes to the achievement of global sustainable development goals, but also represents a strategic foundation for long-term financial stability, competitiveness, and sustainable development of halal enterprises in the global environment (Asmadi & Saimy, 2024; Iqbal, Javed & Bibi, 2025).

## Conclusion

The halal industry today represents one of the most dynamic sectors of the global economy, with a market value projected to grow from USD 7.36 trillion in 2023 to USD 10.89 trillion by 2028 (SESRIC, 2025), while the halal food sector is recording particularly dynamic growth, from USD 1.97 trillion in 2025 to a projected USD 3.66 trillion by 2030 (Research and Markets, 2026). This paper has demonstrated that strategic financial management plays a fundamental role in ensuring the long-term competitiveness and sustainability of halal enterprises, and that digitalisation has significantly expanded its scope by integrating advanced technologies into all key segments of business decision-making.

Artificial intelligence is transforming strategic financial management in the halal sector through three key dimensions: predictive analytics that increases the accuracy of cash flow forecasting to up to 95% (IBM, 2024), automated financial reporting that reduces administrative burden and compliance costs, and intelligent risk management systems that enable timely identification and mitigation of halal-specific risks. The application of these technologies is not merely a matter of operational efficiency, but also a strategic prerequisite for the long-term sustainability of halal enterprises in an increasingly competitive global environment.
Although artificial intelligence significantly enhances operational efficiency and supports the budgeting process, its application in the domain of long-term strategic planning remains limited. Strategic decisions must account for uncertainty, competitive pressures, and market volatility, and it is precisely in these dimensions that artificial intelligence exhibits certain limitations, as it lacks the foresight, adaptability, and creativity necessary to navigate complex strategic challenges (Harvard Business Review, 2024). The human factor therefore remains essential for aligning financial decisions with the strategic objectives of the organisation and for assuming ultimate responsibility for strategic directions of development.

The connection between halal principles and ESG criteria, increasingly referred to by the term "Halal-ESG", opens significant opportunities for positioning the halal industry as a global model of ethical and sustainable business. Sustainable financing instruments, such as green sukuk whose total issuances exceeded USD 20 billion by 2023 (Islamic Finance Development Report, 2023), along with circular economy principles, represent concrete mechanisms for achieving synergy between halal values and ESG criteria. Despite challenges related to regulatory fragmentation, limited access to financing, and human resource competencies, accelerated demographic growth of the Muslim population, technological innovations, and the expansion of Islamic finance are creating a favourable environment for the long-term sustainable development of the halal industry.

The synergy of strategic financial management, digitalisation, and artificial intelligence, together with the integration of ESG principles and halal values, represents a prerequisite for the long-term competitiveness and sustainability of the halal industry in the global environment, enabling it to respond to the challenges of the modern global market while preserving its fundamental values.

## Literatura


Ahmad, I. (2024). Digital transformation and financial management. *Journal of Financial Innovation*, 12(3), 45–67.

Ahmed, S., & Traore, A. (2026). Artificial intelligence in liquidity risk management in Islamic banks: Opportunities and challenges. *Advanced International Journal of Banking, Accounting and Finance*, 8(23), 01–17. https://doi.org/10.35631/AIJBAF.823001

Asmadi, A. S., & Saimy, I. S. (2024). Integration of ESG principles in halal logistics: Advancing sustainable practices in the Islamic supply chain. *International Journal of Research and Innovation in Social Science*, 8(12), 1791–1805.

Firmansyah, I., Adawiyah, W. R., & Setyorini, C. T. (2025). Challenges and strategic responses in halal supply chain integration: A multi-dimensional literature review. *Operations and Supply Chain Management*, 18(4), 617–631.

Gartner. (2024). *Predicts 2025: AI expands its role in enterprise finance*. Gartner Research.

Harvard Business Review. (2024). How AI can help your company set a budget. Preuzeto sa: https://hbr.org/2024/11/how-ai-can-help-your-company-set-a-budget (pristupljeno 19. 4. 2026.)

IBM. (2024). *AI in financial forecasting: Transforming cash flow management*. IBM Institute for Business Value.

Iqbal, Z., Javed, T., & Bibi, R. (2025). Sustainability and ethics in the halal industry. *Journal of Halal Ethics and Research*, 1(1), 52–73. https://doi.org/10.58932/MULJ0008

Islamic Finance Development Report. (2023). *Islamic Finance Development Report 2023: Resilience and Growth*. Refinitiv.

Kalić, I. (2017). *Upravljanje novčanim tokovima – strateški i operativni aspekt*. Tuzla: Visoka škola za finansije i računovodstvo FINra.

Kalić, I., Ćatić, N., & Ćatić, T. (2025). Uticaj digitalne transformacije, umjetne inteligencije i principa održivosti na donošenje strateških i operativnih odluka finansijskog menadžmenta. *Zbornik radova*. Tuzla: Univerzitet FINRA.

Kalić, I., Ćatić, N., & Ćatić, T. (2025). Mjesto i uloga finansijskog menadžmenta u cirkularnoj ekonomiji. *Zbornik radova*. Tuzla: Univerzitet FINRA.

Liquid Web. (2026). AI in inventory management. Preuzeto sa: https://www.liquidweb.com/blog/ai-inventory-management/ (pristupljeno 19. 4. 2026.)

McKinsey & Company. (2025). *The state of AI in 2025: Global survey*. McKinsey Global Institute.

Noviyanti, R., & Hakim, R. (2025). Halal industry growth: Economic opportunities and challenges in global markets. *Jurnal Ilmu Ekonomi dan Bisnis Islam*, 7(1), 18–42.

Phoenix Strategy Group. (2026). How AI predictive analytics improves cash flow forecasting. Preuzeto sa: https://www.phoenixstrategy.group/blog/how-ai-predictive-analytics-improves-cash-flow-forecasting (pristupljeno 18. 4. 2026.)

Research and Markets. (2026). *Halal food market report 2026*. Preuzeto sa: https://www.researchandmarkets.com/reports/5744211

Rovčanin, A. (2006). *Upravljanje finansijama*. Sarajevo: Ekonomski fakultet u Sarajevu.

SESRIC. (2025). *Halal industry in OIC member*

*countries: Challenges and prospects*. Statistical, Economic and Social Research and Training Centre for Islamic Countries.

Silvira, M., Rofi'ah, N., Utami, E., & Endang, S. (2023). Strategic financial management in the digital era. *Asian Journal of Business and Management*, 11(2), 78–94.

Siregar, R., Ramadhan, M., & Kamilah. (2025). Enhancing financial performance of halal MSMEs through intellectual capital and business sustainability in Medan City, Indonesia. *Journal of Islamic Economics Lariba*, 11(1), 129–168.

Wardah, S. (2025). ESG in Brunei's halal industry. *Halalsphere*, 5(1), 41–49.

# STRATEŠKI FINANSIJSKI MENADŽMENT U FUNKCIJI DUGOROČNOG ODRŽIVOG RAZVOJA HALAL INDUSTRIJE U UVJETIMA DIGITALIZACIJE I VJEŠTAČKE INTELIGENCIJE

**Ismet Kalić**

Univerzitet FINRA Tuzla, Mitra Trifunovića Uče 9, 75000 Tuzla, Bosna i Hercegovina

*Autor za korespodenciju: Ismet Kalić*
*E-mail address: ismet.kalic2020@gmail.com*

*Pregledni rad*

## SAŽETAK

Halal industrija prepoznata je kao jedan od najbrže rastućih globalnih sektora, sa značajnom i kontinuirano rastućom tržišnom vrijednošću. Njen održivi razvoj zahtijeva ne samo usklađenost s vjerskim i etičkim standardima, već i primjenu savremenih alata strateškog finansijskog menadžmenta sposobnih da odgovore na izazove dinamičnog poslovnog okruženja. Ovaj rad analizira ulogu strateškog finansijskog menadžmenta u osiguravanju dugoročnog održivog razvoja halal industrije, s posebnim naglaskom na transformacijski potencijal digitalizacije i vještačke inteligencije (AI). Rad je zasnovan na analizi relevantne naučne i stručne literature, pregledu globalnih trendova halal tržišta te komparativnoj analizi dostupnih teoretskih i empirijskih spoznaja iz oblasti strateškog finansijskog menadžmenta i halal industrije. Rad istražuje kako alati zasnovani na vještačkoj inteligenciji, poput prediktivne analitike, automatiziranog finansijskog izvještavanja i inteligentnih sistema upravljanja rizicima, mijenjaju strateško finansijsko odlučivanje u halal sektoru. Integracija vještačke inteligencije i digitalnih tehnologija u procese strateškog finansijskog menadžmenta prepoznata je kao ključni faktor povećanja efikasnosti, transparentnosti i dugoročne održivosti halal preduzeća. Rad također razmatra vezu između halal principa i ESG kriterija (okolišnih, društvenih i upravljačkih) u kontekstu održivog finansiranja. Rad ukazuje da sinergija strateškog finansijskog menadžmenta, digitalizacije i vještačke inteligencije predstavlja pretpostavku dugoročne konkurentnosti i održivosti halal industrije u globalnom okruženju. Ovakav pristup omogućava halal industriji da odgovori na izazove savremenog globalnog tržišta uz očuvanje svojih temeljnih vrijednosti.

**Ključne riječi:** *halal industrija, strateški finansijski menadžment, digitalizacija, vještačka inteligencija, održivi razvoj*

**JOURNAL**
**OF HALAL QUALITY AND CERTIFICATION**

# TOWARDS A GLOBALLY COHERENT OIC HALAL ECOSYSTEM: POSITIONING SMIIC AS SCHEME OWNER AND IFHAB AS MRA PLATFORM

**Çağrı Cankurtaran**

The Standards and Metrology Institute for Islamic Countries, İstanbul Dünya Ticaret Merkezi A1 Blok No: 436 - 437 - 438 K:14 Yeşilköy, Bakırköy - İstanbul / TÜRKİYE, 3414

*Corresponding author: Çağrı Cankurtaran*
*E-mail address: cagri.cankurtaran@smiic.org*

*Review paper*

## ABSTRACT

The global halal market has expanded into a multi-trillion-dollar ecosystem, yet the Organization of Islamic Cooperation (OIC) continues to face serious fragmentation in standards, conformity assessment and accreditation. Multiple national halal standards, competing halal certification bodies (HCBs) and overlapping accreditation arrangements create market confusion, non-tariff barriers and potential inconsistency with World Trade Organization (WTO) disciplines. Several studies underline the lack of a universally accepted halal standard and stress the need for a unified framework in which Standards and Metrology Institute for Islamic Countries (SMIIC), as an OIC institution, plays a central role in harmonization (Lutfika et al., 2022; Abdallah et al., 2021; Azam & Abdullah, 2021; Akbar et al., 2023; Abdallah, 2021; M.A.A. & M.M.M., 2012). Current practice in many OIC Member States, however, diverges from established international conformity assessment and accreditation models and weakens mutual recognition at the global level. This paper develops a conceptual and institutional model for a coherent OIC halal ecosystem based on international good practice in standardization, conformity assessment and accreditation. In the proposed model, SMIIC develops and maintains OIC/SMIIC halal standards and related conformity assessment documents and acts as the halal certification scheme owner; public or private halal certification bodies (HCBs) perform certification; national accreditation bodies conduct halal accreditation using OIC/SMIIC standards; and Islamic Forum for Halal Accreditation Bodies (IFHAB) provides a multilateral mutual recognition arrangement (MRA) under which accredited halal certificates are mutually recognized across participating states. SMIIC registers competent HCBs under a unique, IT-secured halal scheme logo and defends its scheme and marks across international platforms such as ISO, Codex and WTO TBT. The model aims to align OIC halal governance with global conformity assessment practice, reduce technical barriers to trade, protect Muslim consumers and enhance the credibility of OIC as the global reference for halal.

**Keywords:** *Halal standardization, OIC, SMIIC, accreditation, halal certification, mutual recognition (MRA), WTO TBT, harmonization of standards, halal ecosystem, conformity assessment.*

## 1. Background: Fragmentation in the Global Halal Architecture

### 1.1 Multiplicity of halal standards

Scholarly work consistently highlights that there is no globally recognized halal standard, despite at least a dozen or more national and regional standards currently in use (Lutfika et al., 2022; Abdallah et al., 2021; Azam & Abdullah, 2021; Akbar et al., 2023; M.A.A. & M.M.M., 2012). Comparative analyses of key standards – including OIC/SMIIC, Malaysian MS 1500, Indonesian HAS standards and Singapore's MUIS standards – show substantial commonalities rooted in Qur'an and Sunnah, but also material differences in areas such as animal stunning, nonMuslim slaughterers, use of certain enzymes, technical alcohol, and labeling (Lutfika et al., 2022; Abdallah et al., 2021; Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025).

The 2022 comparative analysis of five major standards (OIC/SMIIC 1, UAE/GSO 20551, MS 1500, MUIS, HAS 23000) concludes that fragmentation in material, product and facility requirements restricts the growth of halal industries and explicitly identifies SMIIC as the most appropriate center for harmonization of international halal standards (Lutfika et al., 2022). Similar reviews describe SMIIC as the only OICmandated body with authority to develop standards and accreditation documents on behalf of OIC, aimed at enabling free movement of halal products among OIC members (Azam & Abdullah, 2021; Salam et al., 2023; Kamil et al., 2025; Akbar et al., 2023; Abdallah, 2021).

### 1.2 Divergent certification and accreditation practices

The absence of a single, universally recognized scheme has led to an uncontrolled proliferation of halal certification bodies (HCBs) and halal accreditation bodies (HABs) at national and regional levels (Abdallah et al., 2021; Azam & Abdullah, 2021; Salam et al., 2023; Abdallah, 2021; Latif, 2020; Hosen & Lathifah, 2018). Many HCBs seek multiple recognitions from different accreditation or recognition bodies, increasing costs and complexity for exporters (Azam & Abdullah, 2021; Latif, 2020).

Studies of halal systems in Muslimmajority and nonMuslimmajority countries alike (e.g., Malaysia, Indonesia, UAE, Pakistan, US, EU) report:

- Overlapping and sometimes competing halal accreditation bodies (Azam & Abdullah, 2021; Salam et al., 2023; Abdallah, 2021; Latif, 2020)
- Limited or selective mutual recognition between jurisdictions (Naila et al., 2025; Anita & Sapa, 2025; Latif, 2020; Hosen & Lathifah, 2018)
- Cases of forged halal certificates and misuse or expiration of halal logos (Al-Mahmood & Fraser, 2023; Abdallah, 2021)
- Risk of unethical or criminal practices where oversight is weak (Abdallah, 2021)
- These features deviate from the way conformity assessment and accreditation are organized in other technical fields, where ISO/IEC standards, International Laboratory Accreditation Cooperation / International Accreditation Forum (ILAC/ IAF) MRAs and clear scheme ownership are the norm.

### 1.3 Trade and WTO TBT implications

The multiplicity of national halal requirements has direct implications for market access and WTO consistency. Crosscountry analyses (including Indonesia's export position) show that lack of harmonization, dual certification burdens, and differing regulatory requirements increase costs and constrain exports (Naila et al., 2025; Anita & Sapa, 2025; Wahyudi, 2025; Hosen & Lathifah, 2018).

From a tradelaw perspective, Shariabased halal measures can, in principle, be compatible with WTO rules when designed and applied in a nondiscriminatory way and when justifiable as protecting public morals or consumers (Yuanitasari et al., 2025; Wahyudi, 2025). However, discriminatory or opaque recognition of foreign HCBs, politically driven preference for certain national schemes, or unjustified refusal of certificates from competent foreign bodies may be viewed as technical barriers to trade under the TBT Agreement (Yuanitasari et

al., 2025; Wahyudi, 2025).

Authors therefore emphasize mutual recognition, harmonization of standards, and transparent conformity assessment as key strategies to reconcile halal regulation with WTO disciplines (Naila et al., 2025; Anita & Sapa, 2025; Hamzah et al., 2024; Yuanitasari et al., 2025; Wahyudi, 2025).

## 2. SMIIC's Mandate and Current Position

### 2.1 SMIIC as an OIC standardization and accreditation organization

SMIIC is recognized in the literature as an intergovernmental regional standardization organization mandated by OIC to develop standards and accreditation documents for OIC Member States (Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Abdallah, 2021; Latif, 2020). It has issued a family of OIC/SMIIC standards covering:

- General requirements for halal food (OIC/SMIIC 1)
- Conformity Assessment – Requirements for Bodies Providing Halal Certification (OIC/SMIIC 2)
- Conformity Assessment - Requirements for Halal Accreditation Bodies Accrediting Halal Conformity Assessment Bodies (OIC/SMIIC 3)
- Additional sectors such as cosmetics, tourism and others (Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025)

These standards explicitly draw on ISO/IEC and Codex texts, thereby mirroring mainstream international standardization and conformity assessment structures while embedding Islamic requirements (Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025).

### 2.2 Perception of SMIIC in comparative studies

Comparative studies place SMIIC alongside Malaysian, Indonesian and Singaporean standards as one of the four most influential frameworks globally (Lutfika et al., 2022; Azam & Abdullah, 2021; Salam et al., 2023; Kamil et al., 2025; M.A.A. & M.M.M., 2012). Some analyses observe that, despite being relatively young (first halal standard in 2011), SMIIC has expanded its network of accredited or recognized HCBs and is seen as more flexible than some national standards because it considers all major Sunni schools of law (Azam & Abdullah, 2021; Salam et al., 2023; Kamil et al., 2025).

At the same time, several papers note that SMIIC's standard is not yet adopted or implemented uniformly across OIC countries, and that many national authorities and HCBs still prioritize their domestic standards or recognition regimes over OIC/SMIIC (Abdallah et al., 2021; Azam & Abdullah, 2021; M.A.A. & M.M.M., 2012; Hosen & Lathifah, 2018). One study bluntly states that OIC/SMIIC initiatives "are not taken seriously" by many certification bodies, even though OIC has politically endorsed SMIIC (Hosen & Lathifah, 2018).

The consensus in scholarly work is that SMIIC is the logical center for global halal standard harmonization, but that its potential remains underutilized due to national interests, regulatory sovereignty concerns and competing institutional initiatives (Lutfika et al., 2022; Abdallah et al., 2021; Azam & Abdullah, 2021; Salam et al., 2023; Kamil et al., 2025; Abdallah, 2021; M.A.A. & M.M.M., 2012; Hosen & Lathifah, 2018).

## 3. Conceptual Framework: International Good Practice in Conformity Assessment

Before referring to the OIC halal model, *namely*, OIC Global Halal Quality Infrastructure (OHAQ), it is important to recall how nonhalal sectors are structured globally.

### 3.1 Roles in the conventional conformity assessment ecosystem

In most regulatory and voluntary schemes worldwide:

- **Standards bodies** (e.g., ISO, IEC, national standards bodies) develop normative documents.
- **Scheme owners** (sector regulators, industry associations, or standardization organizations) define specific certification

schemes based on those standards, including scope, rules for use of marks, and oversight mechanisms.
- **Certification bodies (CBs)** – public or private – perform conformity assessment under ISO/IEC standards (e.g., 17065, 17021-1) and scheme rules.
- **Accreditation bodies (ABs)** assess CB competence using ISO/IEC 17011based systems and specific scheme criteria.
- **International MRAs** (ILAC/IAF, regional accreditation cooperations) underpin mutual recognition of certificates and test reports across borders.

This layered architecture separates standardsetting, scheme design, certification and accreditation, while building trust through peerevaluated MRAs and clear governance of marks.

### 3.2 Problems when these roles are blurred

In halal, existing practice frequently blurs these roles: single national entities sometimes play regulator, standard setter, scheme owner, certifier and de facto accreditation body at the same time (Azam & Abdullah, 2021; Salam et al., 2023; Najla & Huda, 2025; Latif, 2020; Hosen & Lathifah, 2018). Literature links such concentration of functions to:

- Fragmentation of recognition and logo systems, confusing consumers and traders (Abdallah et al., 2021; Azam & Abdullah, 2021; Al-Mahmood & Fraser, 2023; Abdallah, 2021)
- Political or protectionist use of certification or recognition to control market access (Naila et al., 2025; Anita & Sapa, 2025; Yuanitasari et al., 2025; Wahyudi, 2025; M.A.A. & M.M.M., 2012)
- Increased opportunities for malpractice and "halal crime" where there is limited external oversight (Abdallah, 2021).

Aligning the OIC halal ecosystem with ISO Committee on Conformity Assessment (ISO/CASCO) and international accreditation practice would reduce these structural vulnerabilities.

## 4. OIC Halal Governance Model - OIC Global Halal Quality Infrastructure (OHAQ)

This section develops a detailed model that places SMIIC as scheme owner within a multilayered structure consistent with global best practice, while leveraging IFHAB as the platform for mutual recognition.

### 4.1 Core principles

The model rests on several principles derived from the literature:

1. **Single normative center for standards** – OIC/SMIIC standards as primary reference for OIC halal requirements (Lutfika et al., 2022; Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Abdallah, 2021; Latif, 2020).
2. **Separation of functions** – distinct roles for SMIIC (standards and scheme owner), HCBs (certification), national ABs (accreditation) and IFHAB (MRA).
3. **Mutual recognition & nondiscrimination** – recognition of accredited halal certificates based on competence and compliance with common standards, not on nationality of the issuing HCB, in line with WTO TBT principles (Naila et al., 2025; Anita & Sapa, 2025; Yuanitasari et al., 2025; Wahyudi, 2025; M.A.A. & M.M.M., 2012).
4. **Transparency & traceability** – ITenabled tracking of certificates and standardized halal logo to prevent fraud and enhance consumer trust (Akbar et al., 2023; Al-Mahmood & Fraser, 2023; Hamzah et al., 2024; Wahyudi, 2025; Abdallah, 2021).
5. **Islamic legitimacy & inclusiveness** – active participation and contribution of International Islamic Fiqh Academy (IIFA) in the standardization process to avoid dominance of one school of thoughts (madhab) and reflect the diversity of OIC (Lutfika et al., 2022; Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Hamzah et al., 2024).

### 4.2 Institutional roles and architecture

#### 4.2.1 SMIIC as standardsetter and halal scheme owner

Building on existing mandates, SMIIC would have a dual, but clearly defined role:

**Standardsetting**:

- Develop,
  - maintain and update the family of OIC/SMIIC halal standards (food, cosmetics, tourism, logistics, etc.), including standards for HCBs and HABs (Lutfika et al., 2022; Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Abdallah, 2021; Latif, 2020).
  - Ensure alignment with ISO/IEC and Codex where appropriate, preserving compatibility with international trade and WTO TBT expectations (Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Wahyudi, 2025).

- **Scheme ownership**:
  - Establish formal OIC/SMIIC Halal Certification Schemes (e.g., "SMIIC Halal Food Scheme", "SMIIC Halal Cosmetics Scheme") that specify:
    - Scope and applicable standards
    - Certification rules and levels of assurance
    - Use of the OIC/SMIIC halal scheme logo
    - Requirements for accreditation and participation in MRAs
  - Govern the intellectual property (IP) of the unique OIC/SMIIC halal mark globally and manage rules of use.
  - Maintain a global registry of recognized HCBs authorized to use the scheme and logo, linked to accreditation status and MRA participation.

This would mirror mainstream scheme owners in other sectors (e.g., major product certification schemes) and responds to calls in the literature for a single global halal standardization and accreditation system centered in SMIIC (Lutfika et al., 2022; Azam & Abdullah, 2021; Salam et al., 2023; Kamil et al., 2025; Abdallah, 2021; M.A.A. & M.M.M., 2012).

### 4.2.2 Halal Certification Bodies (HCBs): public and private

In the model, any competent public or private body may act as an HCB provided it:

- Implements OIC/SMIIC 2 (requirements for HCBs) combined with ISO/IEC 17065, ISO/IEC 17021-1 or equivalent.
- Is accredited for the relevant OIC/SMIIC scheme(s) by an appropriate national AB that itself meets OIC/SMIIC 3.
- Signs contractual agreements with SMIIC on use of the OIC/SMIIC halal logo and agrees to cooperate with SMIIC's ITbased traceability system.

HCBs would continue to serve local industries and exporters, but under a unified scheme architecture, reducing the proliferation of incompatible local logos and proprietary standards (Abdallah et al., 2021; Azam & Abdullah, 2021; Al-Mahmood & Fraser, 2023; Abdallah, 2021; Hosen & Lathifah, 2018).

### 4.2.3 National Accreditation Bodies (ABs) for halal

Each OIC Member State would designate or establish a national accreditation body (or use a regional AB) that:

- Operates in accordance with OIC/SMIIC 3 (Azam & Abdullah, 2021; Salam et al., 2023; Kamil et al., 2025; Latif, 2020).
- Accredits HCBs for OIC/SMIIC halal schemes, ensuring competence and impartiality.
- Participates in IFHAB's MRA peerevaluation processes.
- This maintains state sovereignty over accreditation – a concern frequently raised in the literature – while embedding national ABs in a harmonized OIC framework (M.A.A. & M.M.M., 2012; Hosen & Lathifah, 2018).

### 4.2.4 IFHAB as OIC halal MRA platform

IFHAB could serve as the multilateral MRA and peer-evaluation platform for halal accreditation by:

- Coordinate peer evaluations of ABs against OIC/SMIIC criteria, similar to ILAC/IAF models.
- Administer an IFHAB MRA under which accreditation decisions for OIC/SMIIC schemes are recognized across participating economies.
- Publish a list of signatory ABs and accredited

HCBs whose certificates are eligible for mutual recognition.

Through IFHAB, halal certificates issued by HCBs accredited by an MRAsignatory AB would be deemed trustworthy across other participating markets, removing the need for multiple recertifications and reducing technical barriers to trade (Naila et al., 2025; Anita & Sapa, 2025; Hamzah et al., 2024; Yuanitasari et al., 2025; Wahyudi, 2025; M.A.A. & M.M.M., 2012).

### 4.3 Central role of a unified OIC/SMIIC halal logo and IT traceability

A common problem in halal markets is confusion from numerous halal logos and recurring instances of falsified or expired marks (Abdallah et al., 2021; Azam & Abdullah, 2021; Al-Mahmood & Fraser, 2023; Abdallah, 2021). The proposed model addresses this by:

- Creating a single OIC/SMIIC halal logo for each scheme, owned by SMIIC and used globally by authorized HCBs.
- Linking every issued certificate and logo to a central IT platform operated (or mandated) by SMIIC, integrating data from HCBs and ABs via secure APIs.
- Allowing regulators, businesses and consumers to verify certificates and logo validity through QRcodes or other digital tools.

Research on halal regulatory systems emphasizes traceability and verification as critical to consumer trust and to controlling fraud in complex supply chains (Akbar et al., 2023; Al-Mahmood & Fraser, 2023; Hamzah et al., 2024; Wahyudi, 2025; Abdallah, 2021). Blockchain or other distributed ledger technologies could be incorporated as a technical option for immutable recording of certification events.

**Standard Markdown Table: Key Functions in the Proposed Model**

**Table 1:** Proposed roles across SMIIC-based halal governance.

| Function / Role | Main Responsibilities | Actor in Model | Citations |
|---|---|---|---|
| Standard setting | Develop OIC/SMIIC halal standards, alignment with ISO/Codex | SMIIC | (Lutfika et al., 2022; Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Abdallah, 2021; Latif, 2020) |
| Scheme ownership | Define halal schemes, govern logo, register CBs | SMIIC | (Lutfika et al., 2022; Azam & Abdullah, 2021; Salam et al., 2023; Kamil et al., 2025; Abdallah, 2021; M.A.A. & M.M.M., 2012; Latif, 2020) |
| Certification | Audit, decision, certificate issuance, data feed to IT | Public/private HCBs | (Abdallah et al., 2021; Azam & Abdullah, 2021; Al-Mahmood & Fraser, 2023; Abdallah, 2021; Latif, 2020; Hosen & Lathifah, 2018) |
| Accreditation | Assess HCB competence to OIC/SMIIC and ISO criteria | National ABs | (Azam & Abdullah, 2021; Salam et al., 2023; Kamil et al., 2025; Abdallah, 2021; M.A.A. & M.M.M., 2012; Latif, 2020) |
| MRA & peer evaluation | Evaluate ABs, operate MRA, list signatories | IFHAB | (Naila et al., 2025; Anita & Sapa, 2025; Hamzah et al., 2024; Yuanitasari et al., 2025; Wahyudi, 2025; M.A.A. & M.M.M., 2012) |

## 5. Alignment of with Global Conformity Assessment and WTO TBT

### 5.1 Convergence with ISO/CASCO, ILAC/IAF practice

The model converges with established global practice in several ways:

- Use of OIC/SMIIC standards as *sectorspecific* normative documents, combined with generic ISO/IEC standards (e.g., 17065, 17011).
- Clear scheme ownership separating scheme design from certification and accreditation.
- Peerevaluated MRA for accreditation

decisions, similar to ILAC/IAF arrangements.

Literature on halal and on other regulated sectors stresses that harmonization and the use of international standards are key criteria under the WTO TBT Agreement and reduce the risk that technical regulations or conformity assessment procedures become unnecessary obstacles to trade (Naila et al., 2025; Akbar et al., 2023; Anita & Sapa, 2025; Hamzah et al., 2024; Yuanitasari et al., 2025; Wahyudi, 2025). By adopting this architecture, OIC can argue that OIC/SMIICbased halal requirements are consistent with international good practice, are nondiscriminatory and are based on widely recognized standards.

### 5.2 WTO SPS/TBT and public morals

Comparative legal studies show that halal requirements can be justified under WTO law when they pursue legitimate objectives such as protection of public morals, religionbased consumer preferences and food safety, and when applied in a nondiscriminatory and transparent manner (Yuanitasari et al., 2025; Wahyudi, 2025). However, discriminatory or opaque recognition of foreign certificates – for example, preferring some national HCBs for political reasons while rejecting equivalently competent foreign HCBs – would raise concerns under Most-Favoured-Nation (MFN) and national treatment provisions (Yuanitasari et al., 2025; Wahyudi, 2025).

The proposed SMIIC–IFHAB–AB–HCB model addresses these concerns by:

- Basing recognition on objective competence criteria, not nationality.
- Using MRAevaluated ABs and common OIC/SMIIC standards as the basis for acceptance of certificates.
- Providing transparent, ITbased verification of certificates and marks.

This can be explicitly framed as halal diplomacy and norm entrepreneurship by OIC, positioning the OIC/SMIIC system as a bridge between halal norms and the secular global trade regime (Naila et al., 2025; Anita & Sapa, 2025; Hamzah et al., 2024; Yuanitasari et al., 2025; Wahyudi, 2025).

## 6. Addressing Current OIC Challenges through the Model

### 6.1 National sovereignty and regulatory autonomy

One of the central political obstacles to a global halal standard is concern that states would need to "surrender" sovereignty over religious and regulatory matters (Abdallah et al., 2021; Azam & Abdullah, 2021; M.A.A. & M.M.M., 2012; Hosen & Lathifah, 2018). The model mitigates this by:

Leaving legal and regulatory decisions (e.g., mandatory vs voluntary certification, enforcement) to each state.

Allowing states to designate their own national ABs and decide which sectors to bring under the OIC/SMIIC scheme.

Using IFHAB's MRA as a voluntary, treatylike instrument, consistent with WTO's encouragement of mutual recognition.

States therefore retain control over domestic law, while benefiting from a shared technical infrastructure that reduces costs and expands export opportunities (Naila et al., 2025; Anita & Sapa, 2025; Hamzah et al., 2024; Wahyudi, 2025; M.A.A. & M.M.M., 2012).

### 6.2 Market access, cost and SME participation

Studies on Indonesia, Malaysia and other countries show that fragmented halal regimes, dual certification and inconsistent recognition significantly increase compliance costs, especially for SMEs (Naila et al., 2025; Anita & Sapa, 2025; Wahyudi, 2025; Hosen & Lathifah, 2018).

Under this model:

- Manufacturers can certify once with an HCB accredited for OIC/SMIIC schemes by an MRAsignatory AB.
- Their certificates and logo would then be recognized in multiple OIC markets participating in the MRA, subject to local regulatory requirements.
- Digital verification tools reduce transaction costs and disputes in supply chains.

This aligns with calls in the literature for

harmonization and mutual recognition to unlock the full potential of the global halal market (Lutfika et al., 2022; Naila et al., 2025; Akbar et al., 2023; Hamzah et al., 2024; Abdallah, 2021; M.A.A. & M.M.M., 2012).

### 6.3 Consumer trust, Islamic legitimacy and prevention of halal crime

Research documents how inconsistent standards, weak oversight and proliferation of logos undermine consumer confidence and, in some cases, facilitate fraud and organized crime (Al-Mahmood & Fraser, 2023; Hamzah et al., 2024; Abdallah, 2021).

By:

- Embedding IIFA fatwas at SMIIC and AB levels,
- Standardizing training and competence criteria for HCB auditors and Islamic affairs experts, and
- Ensuring realtime verification of certificates and logos,

the model strengthens both fiqhi legitimacy and regulatory effectiveness, thereby reducing the space for malpractice (Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Hamzah et al., 2024; Abdallah, 2021; Latif, 2020).

## 7. Implementation Roadmap for SMIIC and IFHAB

A phased approach is advisable, with the following stages providing a structured pathway for normative consolidation, institutional alignment, and eventual global implementation.

### Phase 1: Normative consolidation

Complete and regularly update the OIC/SMIIC standards covering halal food, cosmetics, tourism, logistics and other sectors, incorporating emerging issues (e.g., novel foods, biotechnology).

Finalize and publish formal scheme rules (scheme documents) for each sector, including logo rules and recognition criteria.

Include IIFA contribution at SMIIC to address controversial issues and maintain consistency (Lutfika et al., 2022; Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Hamzah et al., 2024).

### Phase 2: Institutional alignment and capacity building

Work with OIC Member States to align national halal regulations and technical standards with OIC/SMIIC texts.

Support the development or designation of halalcompetent national ABs and their adoption of OIC/SMIIC 3.

Provide training to HCBs and regulators on the new scheme architecture and IT tools (Naila et al., 2025; Azam & Abdullah, 2021; Akbar et al., 2023; Kamil et al., 2025; Hamzah et al., 2024; Latif, 2020).

### Phase 3: Launch of IFHAB MRA and global registry

Operationalize IFHAB's peerevaluation process for ABs and establish the first set of MRA signatories.

Launch the OIC/SMIIC global HCB registry and unique halal logo system.

Deploy the central IT platform (possibly incorporating blockchain for critical chains) for certificate and logo validation (Akbar et al., 2023; Al-Mahmood & Fraser, 2023; Hamzah et al., 2024; Wahyudi, 2025; Abdallah, 2021).

### Phase 4: International engagement and protection of rights

Engage with ISO, Codex and WTO committees (especially TBT and SPS) to:

Notify OIC/SMIIC schemes as relevant international standards.

Clarify how the system supports nondiscrimination, transparency and trade facilitation.

Register and protect OIC/SMIIC halal logos as trademarks or certification marks in key jurisdictions.

Promote the OIC/SMIIC scheme in dialogue with nonOIC trading partners and major import markets.

## 8. Conclusion

The literature clearly recognizes both the urgency and the difficulty of harmonizing halal standards and practices across OIC and beyond. Existing national and regional arrangements have generated a patchwork of requirements and logos that burden trade, confuse consumers and risk inconsistency with broader international trade rules. SMIIC, as an OIC institution with a mandate to develop standards and accreditation documents, is repeatedly identified as the natural center for a coherent global halal framework (Lutfika et al., 2022; Abdallah et al., 2021; Azam & Abdullah, 2021; Salam et al., 2023; Akbar et al., 2023; Kamil et al., 2025; Abdallah, 2021; M.A.A. & M.M.M., 2012; Latif, 2020; Hosen & Lathifah, 2018).

By explicitly positioning SMIIC as the halal certification scheme owner, empowering national accreditation bodies and IFHAB within an MRAbased architecture, and deploying a unified halal logo backed by robust ITenabled traceability, OIC can align halal governance with international conformity assessment best practice and WTO norms. This model preserves national sovereignty, strengthens Shariah legitimacy, enhances consumer trust and facilitates freer movement of halal products across borders.

For SMIIC and IFHAB, the challenge ahead is not merely technical; it is also diplomatic and political. It requires sustained engagement with Member States, national regulators, private HCBs and international organizations, coupled with a clear narrative: that a unified, transparent and competencebased OIC/SMIIC halal ecosystem is not only consistent with global practice but fundamentally in the interest of Muslim consumers, halal industries and the credibility of Islamic norms in the global economy.

## References

Wahyudi. (2025). Challenges and Opportunities of Integration of Islamic Law with International Standards in Global Trade. *Jurnal Hukum Ekualitas*, *1*(1), 18-31. https://doi.org/10.56607/wswjn858

Abdallah, A., Rahem, M., & Pasqualone, A. (2021). The multiplicity of halal standards: a case study of application to slaughterhouses. *Journal of Ethnic Foods, 8*, 1-15. https://doi.org/10.1186/s42779-021-00084-6

Abdallah, A. (2021). Has the Lack of a Unified Halal Standard Led to a Rise in Organised Crime in the Halal Certification Sector?. *Forensic Sciences*. https://doi.org/10.3390/forensicsci1030016

Akbar, J., Gul, M., Jahangir, M., Adnan, M., Saud, S., Hassan, S., Nawaz, T., & Fahad, S. (2023). Global Trends in Halal Food Standards: A Review. *Foods, 12*. https://doi.org/10.3390/foods12234200 Al-Mahmood, O., & Fraser, A. (2023). Perceived challenges in implementing halal standards by halal certifying bodies in the United States. *PLOS ONE, 18*. https://doi.org/10.1371/journal.pone.0290774

Anita, K., & Sapa, N. (2025). Harmonisasi Standar Sertifikasi Halal Internasional dalam Perspektif Fikih Muamalah: Analisis Diplomasi Ekonomi Halal Indonesia di Pasar Global. *AL-KHIYAR: Jurnal Bidang Muamalah dan Ekonomi Islam*. https://doi.org/10.36701/al-khiyar.v5i2.2333

Azam, M. S. E., & Abdullah, M. A. (2021). Halal Standards Globally: A Comparative Study of Unities and Diversities Among the Most Popular Halal Standards Globally. *Halalsphere*, *1*(1), 11–31. https://doi.org/10.31436/hs.v1i1.20

Hamzah. S. A. S., Johari, S., Yusof, Y. A., Ramlan, M. A., & Azmi, P. U. B. M.(2024).A Structured Review: Halal Regulatory System .Journal of Tourism Hospitality and Environment Management, 9(38), 259-289. https://doi.org/10.35631/jthem.938018

Hosen, M. N. and Lathifah, F. (2020). Comparison of Halal Certification in Several Countries toward Halal Standard of Indonesia. In *Proceedings of the 1st International Conference on Recent Innovations - ICRI*; ISBN 978-989-758-458-9, SciTePress, pages 201-210. https://doi.org/10.5220/0009921502010210

Kamil,A.,Hatta,F.A.M.,&AbdGhafarIsmail.(2025). Comparative study: Analysis of halal standards of the food industry in Islamic countries. *Multidisciplinary Reviews*, *8*(8), 2025257. https://doi.org/10.31893/multirev.2025257

Latif, M.A. (2020). Halal International Standards and Certification. In The Halal Food Handbook (eds Y.R. Al-Teinaz, S. Spear and I.H.A. Abd El Rahim). https://doi.org/10.1002/9781118823026.ch14

Lutfika, E., Kusnandar, F., & Hunaefi, D. . (2022). Comparative Analysis and Harmonization of Global Halal Standards. *International Journal of Halal Research*, *4*(1), 29–39. https://doi.org/10.18517/ijhr.4.1.29-39.2022

M.A.A., H., & M.M.M., S. (2012). The possibility of uniformity on Halal standards in organization of Islamic Countries (OIC) country. World Applied Sciences Journal, Volume 17 (Towards the Traceability of Halal and Thoyyiban Application), 12

https://www.idosi.org/wasj/wasj17(TTHTA)12/2.pdf

Naila Naila, Risma Risma, Diana Putri Utari, Anabilla Alma Widyaningtias, & Lina Marlina. (2025). Implikasi Standar Sertifikasi Halal Internasional terhadap Perdagangan Global Indonesia pada Produk Halal. *JURNAL RISET MANAJEMEN DAN EKONOMI (JRIME)*, *3*(4), 185–201. https://doi.org/10.54066/jrime.v3i4.3564

Najla, N., & Fatwa, N. (2025). Halal Certification Policies in OIC and Non-OIC Countries: A Comparative Analysis of Indonesia, Malaysia, Thailand, And Singapore. *International Journal of Islamic Business and Management Review*, *5*(1), 53–67. https://doi.org/10.54099/ijibmr.v5i1.1365

Salam, S. A., Mohd, H., Muflih, B. K., & Jaiyeoba, H. B. (2023). Halal industry and standardization. *Ekonomski izazovi*, *12*(24), 20-30. https://doi.org/10.5937/ekoizazov2324020s

Yuanitasari, D., Harrieti, N., & Salaeh, Y. . (2025). Harmonizing Sharia-Based Halal Standards with International Trade Law: A Comparative Legal Study. *Lampung Journal of International Law*, *7*(1), 47–62. https://doi.org/10.25041/lajil.v7i1.4468

# PREMA GLOBALNO KOHERENTNOM OIC HALAL EKOSISTEMU: POZICIONIRANJE SMIIC-A KAO VLASNIKA ŠEME I IFHAB-A KAO MRA PLATFORME

**Çağrı Cankurtaran**

Institut za standarde i metrologiju za islamske zemlje, İstanbul Dünya Ticaret Merkezi A1 Blok No: 436 - 437 - 438 K:14 Yeşilköy, Bakırköy - İstanbul / Turska, 34149

*Autor za korespodenciju: Çağrı Cankurtaran*
*E-mail address: cagri.cankurtaran@smiic.org*

*Pregledni rad*

## SAŽETAK

Globalno halal tržište se proširilo u višetrilionski ekosistem, ali Organizacija islamske saradnje (OIC) i dalje se suočava sa ozbiljnom fragmentacijom u standardima, ocjenjivanju usklađenosti i akreditaciji. Višestruki nacionalni halal standardi, konkurentska tijela za halal certificiranje (HCB), kao i preklapajući sistemi akreditacije stvaraju zabunu na tržištu, netarifne barijere i potencijalnu neusklađenost sa pravilima Svjetske trgovinske organizacije (WTO). Nekoliko studija naglašava nedostatak univerzalno prihvaćenog halal standarda i ističe potrebu za jedinstvenim okvirom u kojem SMIIC, kao institucija OIC-a, ima centralnu ulogu u harmonizaciji (Lutfika et al., 2022; Abdallah et al., 2021; Azam & Abdullah, 2021; Akbar et al., 2023; Abdallah, 2021; M.A.A. & M.M.M., 2012). Međutim, trenutna praksa u mnogim državama članicama OIC-a odstupa od međunarodno uspostavljenih modela ocjenjivanja usklađenosti i akreditacije, što slabi sistem međusobnog priznavanja na globalnom nivou. Ovaj rad razvija konceptualni i institucionalni model koherentnog OIC halal ekosistema zasnovanog na međunarodnoj dobroj praksi u standardizaciji, ocjenjivanju usklađenosti i akreditaciji. U predloženom modelu, SMIIC razvija i održava OIC/SMIIC halal standarde i povezane dokumente za ocjenu usklađenosti te djeluje kao vlasnik halal šeme certificiranja; javna ili privatna halal certifikacijska tijela (HCB) provode certificiranje; nacionalna akreditacijska tijela vrše halal akreditaciju koristeći OIC/SMIIC standarde; a IFHAB osigurava multilateralni sporazum o međusobnom priznavanju (MRA) u okviru kojeg se akreditirani halal certifikati međusobno priznaju među državama učesnicama. SMIIC registruje kompetentna HCB tijela pod jedinstvenim, IT-zaštićenim halal logotipom šeme i štiti svoju šemu i oznake na međunarodnim platformama kao što su ISO, Codex i WTO TBT. Ovaj model ima za cilj usklađivanje halal upravljanja OIC-a sa globalnom praksom ocjenjivanja usklađenosti, smanjenje tehničkih barijera u trgovini, zaštitu muslimanskih potrošača i jačanje kredibiliteta OIC-a kao globalnog referentnog autoriteta za halal.

**Ključne riječi:** *Halal standardizacija, OIC, SMIIC, akreditacija, halal certificiranje, međusobno priznavanje (MRA), WTO TBT, harmonizacija standarda, halal ekosistem, ocjenjivanje usklađenosti.*

**JOURNAL**
**OF HALAL QUALITY AND CERTIFICATION**

# INTEGRATION OF ISLAMIC ETHICAL PRINCIPLES INTO BUSINESS STRATEGIES OF SUSTAINABLE ECONOMIC SYSTEMS

**Amela Semić [1], Ema Obralić[2], Belmin Poljić [3], Arman Hodžić[4]**

[1]AS Holding d.o.o. Sarajevo, Paromlinska 43, 71000 Sarajevo, Bosnia and Herzegovina
[2]Solana d.d.Tuzla, Soli 3, 75000 Tuzla, Bosnia and Herzegovina
[3]Solana d.d.Tuzla, Soli 3, 75000 Tuzla, Bosnia and Herzegovina
[4]University of Sarajevo – Veterinary Faculty, Zmaja od Bosne 90, 71000 Sarajevo, Bosnia and Herzegovina

*Corresponding author: Ema Obralić*
*E-mail address: ema.obralic@solana.ba*

*Review paper*

## ABSTRACT

The modern concept of the circular economy is based on the efficient use of resources, waste reduction, and the reuse of by-products in production processes. Such an approach is largely compatible with Islamic ethical principles that emphasize responsible management of natural resources and the prohibition of wastefulness. In particular, the concepts of *israf* (prohibition of wastefulness), *khalifa* (human responsibility as steward of the Earth), *mizan* (balance in nature), and *tayyib* (purity and safety of products) represent an important normative framework for the development of sustainable production models in the halal industry.

The aim of this paper is to investigate the possibilities of applying circular economy principles through the valorization of sludge generated during the purification process of raw saline water. Special focus is placed on the mineral sludge produced during the treatment process, which may represent a potential secondary raw material for use in animal feed.

In order to assess the safety and application potential of the analyzed material, experimental laboratory investigations were conducted, including physicochemical analyses, FTIR spectroscopic analysis, and heavy metal content analysis. The obtained physicochemical analysis results indicate a stable mineral composition of the sample, while microbiological examinations did not reveal the presence of pathogenic microorganisms. Heavy metal analysis showed concentrations below the permissible limits prescribed by relevant safety standards. FTIR analysis showed that the sludge contains a dominant share of CaO (80.50%), clearly confirming the presence of calcium carbonate as the main component. Such a mineral composition indicates the potential of the sludge to be used as a calcium source in animal feed, since $CaCO_3$ is widely used as a mineral supplement in the feed industry.

The obtained results indicate that controlled treatment and appropriate technological preparation of the generated sludge may represent a sustainable solution within circular production systems. The integration of Islamic ethical principles with modern concepts of the circular economy can contribute to waste reduction, more efficient resource utilization, and the development of sustainable production models in accordance with halal and *tayyib* standards.

**Keywords:** *circular economy, sludge, israf, khalifa, mizan, tayyib, FTIR, heavy metals, microbiology, animal feed, halal*

## Introduction

Modern industrial development and the growing need to preserve natural resources have led to the development of the circular economy concept, whose primary goal is waste reduction and the maximum utilization of existing resources through their reuse and valorization. Unlike linear production models based on the principle of "take–make–dispose," the circular economy promotes sustainable production systems in which by-products and waste become valuable secondary raw materials. Such an approach contributes to environmental protection, more rational use of natural resources, and long-term economic sustainability.

The modern concept of the circular economy is based on the efficient use of resources, waste reduction, and the reuse of by-products in production processes. The transition from a linear to a circular business model enables organizations to reduce production costs, increase resource efficiency, and minimize negative environmental impacts. Within such systems, strategies such as recycling, material reuse, supply chain optimization, and product design for long-term sustainability are applied. This approach is aligned with the Sustainable Development Goals (SDGs), particularly in the areas of responsible production and consumption, and is compatible with Islamic ethical principles that emphasize the prohibition of wastefulness (*israf*) and responsible management of natural resources.

The principles of the circular economy are largely compatible with Islamic ethical teachings, which emphasize human responsibility toward nature and prohibit excessive exploitation of resources. Through the principles of *israf* (prohibition of wastefulness), *khalifa* (the role of humans as stewards of the Earth), *mizan* (maintaining balance in nature), and *tayyib* (product safety and quality), Islam promotes sustainable and responsible business practices. These principles represent an important normative framework for the development of the halal industry based on ethical and sustainable production models.

A particularly important aspect of modern sustainable systems is reflected in finding new opportunities for the valorization of industrial by-products. One such example is the sludge generated during the purification process of raw saline water. Its mineral composition may represent significant potential for further application, particularly in animal nutrition as a source of mineral supplements.

The aim of this paper is to investigate the possibilities of applying circular economy principles through the valorization of sludge generated during the purification process of raw saline water and to analyze its potential application in animal feed in accordance with sustainability principles and halal standards.

## Materials and Methods

The subject of this research was sludge generated during the purification process of raw saline water. Sampling was carried out directly from the contact bed reactor, where chemical precipitation reactions and solid phase formation take place. At the time of sampling, the sludge was in a liquid state, making it necessary to allow it to settle in order to enable natural sedimentation and separation of the lighter and heavier phases.

After a sufficient settling period, the upper layer of purified saline water was carefully decanted. The remaining heavier phase, rich in mineral precipitates, was transferred to a filter press, where mechanical separation of excess water and formation of a sludge cake were performed. This procedure enabled the production of a compact and stable sample suitable for further laboratory processing.

The obtained sludge cake was then dried in an oven at a temperature of 110 °C for one hour in order to remove the remaining moisture content and stabilize the material. The prepared dry sludge sample was subsequently used for all further analyses.

Standard laboratory physicochemical methods were used in this research. Physicochemical examinations included the determination of the mineral composition of the sample, moisture content, and the basic chemical characteristics of the material.

For a more detailed identification of functional groups and mineral composition, FTIR (Fourier Transform Infrared Spectroscopy) analysis was performed. Experimental conditions: the sample was exposed to infrared radiation in the wavenumber range of 4000 to 400 $cm^{-1}$ using an IR Spirit infrared spectrophotometer.

Additionally, heavy metal content analysis was conducted in order to assess the compliance of the sample with relevant safety standards for use in animal feed.

The obtained results were analyzed using qualitative and comparative methods, with particular focus placed on the possibilities of integrating the research findings into sustainable and halal production systems based on the principles of the circular economy.

## Results and Discussion

The results of the physicochemical analyses showed a stable mineral composition of the analyzed sludge, indicating the possibility of its further technological valorization. In order to identify functional groups and determine the chemical composition of the sludge, FTIR analysis was performed, in which the sample was exposed to infrared radiation in the wavenumber range of 4000 to 400 $cm^{-1}$ using an IR Spirit infrared spectrophotometer.

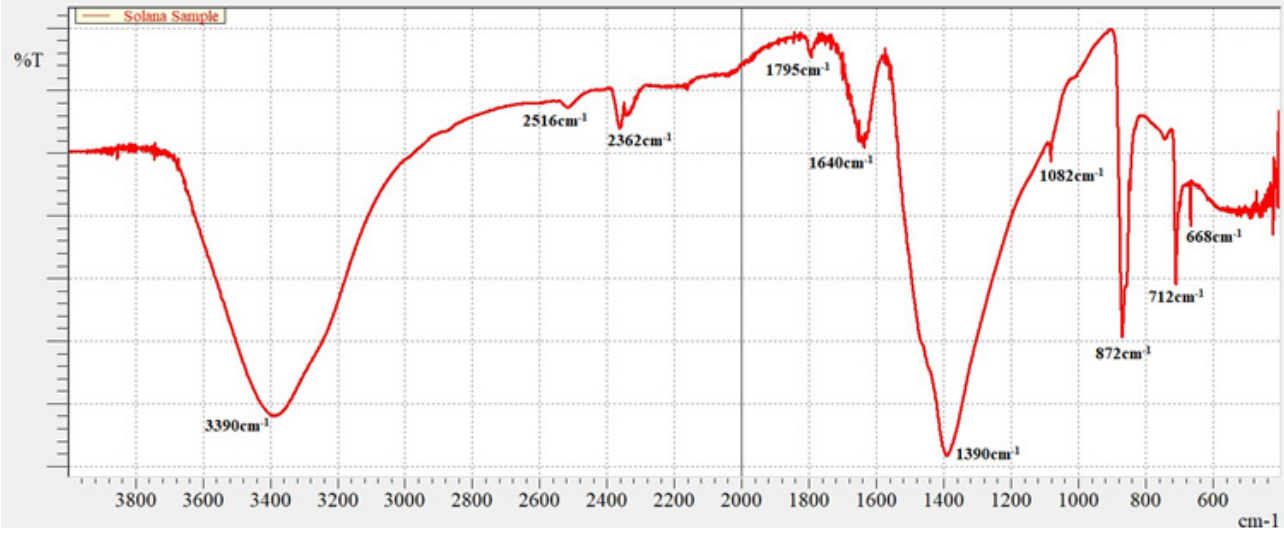


Figure 1. FTIR spectrum of the analyzed sample

By comparison with relevant databases and scientific literature, it was determined that the analyzed sample has a predominantly calcium carbonate ($CaCO_3$) structure. In Figure 1, peaks characteristic of calcium carbonate are marked at the following wavenumber values: 712, 872, 1082, 1390, 1795, and 2516 $cm^{-1}$. The presence of water in the sample was confirmed by peaks at 3390 and 1640 $cm^{-1}$. The appearance of a peak at 2362 $cm^{-1}$ indicates the presence of carbon dioxide from the air. At the value of 668 $cm^{-1}$, a subtle peak is noticeable, most likely originating from residues of compounds containing chlorine atoms in their structure.

The most commonly identified metals in sludge from raw saline water are lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr), nickel (Ni), copper (Cu), and zinc (Zn). These elements have a pronounced toxic potential, accumulate in sediments, and pose a risk to the environment and human health if they enter the food chain.

Table 1. Presentation of the presence and concentration data of heavy metals

| No. | Parameter | Result | Unit |
|---|---|---|---|
| 1. | Arsenic (As) | 0.000 | mg/kg |
| 2. | Copper (Cu) | 0.000 | mg/kg |
| 3. | Mercury (Hg) | 48.44 | µg/kg |
| 4. | Zinc (Zn) | 5.182 | mg/kg |
| 5. | Iron (Fe) | 238 | mg/kg |

The analysis of heavy metal content showed concentrations below the maximum permissible limits prescribed by relevant safety standards, thereby confirming the possibility of its potential application in animal feed.

The obtained results indicate that the analyzed sludge may have a significant role as a secondary raw material within circular production systems. Calcium carbonate is widely used as a mineral supplement in the animal feed industry, and the presence of a high proportion of this compound further confirms the potential practical application of the investigated material.

From the perspective of Islamic business ethics and sustainability, such an approach represents an example of responsible resource management in accordance with the principles of israf and khalifa. The application of sustainable financial strategies plays a significant role in the development of competitive and environmentally responsible production systems. The integration of environmental, social, and governance (ESG) criteria into business decisions enables organizations to attract sustainable investments and develop business models based on the principles of the green economy. In the context of this research, the valorization of sludge as a secondary raw material may contribute to reducing waste management costs and creating additional economic value. Strategies involving sustainable technologies, rational resource use, and reduction of environmental risks contribute to strengthening market competitiveness and the development of sustainable production systems in accordance with halal standards and principles of social responsibility.

The modern development of green technology and sustainable innovation represents one of the key factors in the transition toward sustainable industrial systems. Technologies based on a responsible relationship toward the environment enable the reduction of negative ecological impacts, increased energy efficiency, and more rational use of natural resources. Of particular importance are environmental management systems such as EMAS (Eco-Management and Audit Scheme), which enable organizations to assess and improve their environmental impact through continuous monitoring and the implementation of sustainable business standards. The integration of green technologies with halal and tayyib principles can contribute to the development of safer, more competitive, and more sustainable production models aligned with modern market and environmental protection requirements.

Instead of disposing of by-products as waste, their reuse contributes to reducing negative environmental impacts and promoting more rational use of natural resources. Furthermore, the concept of tayyib particularly emphasizes the importance of product safety and quality, which has been confirmed by the results of the conducted analyses.

The discussion of the results shows that the integration of Islamic ethical principles with the concept of the circular economy can contribute to the development of more sustainable production models in the halal industry. In addition to environmental benefits, such an approach may also have significant economic effects through the reduction of waste management costs and the creation of new value from industrial by-products.

## Conclusion

The research results showed that the sludge generated during the purification process of raw saline water possesses significant potential for valorization within circular production systems. The analyses confirmed a stable mineral composition and heavy metal concentrations below the permissible limits, indicating the possibility of its safe application in animal feed.

The dominant content of calcium carbonate confirms the potential use of the analyzed material as a calcium source in the animal feed industry, whereby an industrial by-product is transformed into a useful secondary raw material. In this way, the fundamental principles of the circular economy are achieved through waste reduction and more efficient resource utilization.

The integration of Islamic ethical principles such as the prohibition of wastefulness (israf), preservation of natural balance (mizan), and responsible resource management

(khalifa) with modern concepts of sustainable development may represent an important model for the development of the future halal industry. Such an approach contributes not only to environmental and economic sustainability, but also to the development of ethically responsible production systems based on the principles of safety, quality, and social responsibility.

## References

BAS 1049:2023. Opći zahtjevi za halal proizvode – Agencija za standardizaciju Bosne i Hercegovine (BAS), Sarajevo.

OIC/SMIIC 1:2011. General Requirements for Halal Food. Organisation of Islamic Cooperation – Standards and Metrology Institute for Islamic Countries (OIC/SMIIC), Istanbul.

OIC/SMIIC 4:2018. Halal Cosmetics – General Requirements. Organisation of Islamic Cooperation – Standards and Metrology Institute for Islamic Countries (OIC/SMIIC), Istanbul.

Agencija za certificiranje halal kvalitete Bosne i Hercegovine. Halal turizam – Generalni zahtjevi. Prezentacija, 2025.

The Circular Economy from the Perspective of Islamic Economics: Advancing a Sustainable Halal Production Model. (2026). ResearchGate.

Gilani, H. (2025). Bridging Islamic Ethics and Circular Economy: Towards a Halal Circular Economy Framework. Values for Impact Conference, Sarajevo.

Journal of Halal Quality and Certification. (2024). Halal Industry, Sustainability and Quality Standards.

Febriandika, N. R. (2025). Supply Chain Transformation of Halal Industry in the Food Sector Through Circular Economy Approaches. Journal of Sustainable Halal Supply Chain, 5(2), 45–61.

Javaid, O. (2022). The Principles of a Circular Economy in the Light of Islamic Values and Beliefs. Journal of Islamic Economics and Sustainability, 7(1), 21–34.

Shovkhalov, S. (2024). Role of Halal Industry in the Development of Green Economy. BIO Web of Conferences, 32, 03009.

Iqbal, Z. (2025). Sustainability and Ethics in the Halal Industry. Journal of Halal Economy Research, 4(1), 15–28.

Firdous, Q. (2025). Islamic Ethical Foundations for a Just and Ecological Future. Islamic Studies and Muslim Societies Journal, 3(2), 55–70.

Ellen MacArthur Foundation. (2019). Circular Economy Introduction and Principles. Dostupno na: Ellen MacArthur Foundation

Ali, F. (2018). The Halal Economy: An Overview of the Global Market. London: Palgrave Macmillan.

Khan, Z., & Yusuf, H. (2020). Integrating Blockchain Technology in the Halal Supply Chain. Journal of Emerging Technologies in Business, 11(3), 45–62.

Ahmad, R., & Mohd, S. (2021). Sustainability and Ethics in the Halal Industry: A Conceptual Framework. Journal of Islamic Business Studies, 15(2), 89–104.

Lamponi, S., Barletta, R., & Santucci, A. (2025). Agricultural and Agro-Industrial Residues as Sustainable Sources of Next-Generation Biomedical Materials. Life, 15(12), 1908

# INTEGRACIJA ISLAMSKIH ETIČKIH PRINCIPA U POSLOVNE STRATEGIJE ODRŽIVIH SISTEMA PRIVREDE

**Amela Semić [1], Ema Obralić[2] , Belmin Poljić [3], Arman Hodžić[4]**

[1]AS Holding d.o.o. Sarajevo, Paromlinska 43, 71000 Sarajevo, Bosnia and Herzegovina
[2]Solana d.d. Tuzla, Soli 3, 75000 Tuzla, Bosna i Hercegovina
[3] Solana d.d. Tuzla, Soli 3, 75000 Tuzla, Bosna i Hercegovina
[4] Univerzitet u Sarajevu, Veterinarski fakultet, Zmaja od Bosne 90, 71000 Sarajevo, Bosna i Hercegovina

*Autor za korespodenciju: Ema Obralić*
*E-mail address: ema.obralic@solana.ba*

*Pregledni rad*

## SAŽETAK

Savremeni koncept cirkularne ekonomije temelji se na efikasnom korištenju resursa, smanjenju otpada i ponovnoj upotrebi nusproizvoda u proizvodnim procesima. Ovakav pristup u velikoj mjeri je kompatibilan sa islamskim etičkim principima koji naglašavaju odgovorno upravljanje prirodnim resursima i zabranu rasipanja. Posebno se izdvajaju koncepti israf (zabrana rasipanja), khalifa (odgovornost čovjeka kao upravitelja Zemlje), mizan (ravnoteža u prirodi) i tayyib (čistoća i sigurnost proizvoda), koji predstavljaju važan normativni okvir za razvoj održivih modela proizvodnje u halal industriji. Cilj ovog rada je istražiti mogućnosti primjene principa cirkularne ekonomije kroz valorizaciju taloga nastalog u procesu prečišćavanja sirove slane vode. Poseban fokus stavljen je na mineralni talog koji nastaje tokom procesa obrade, a koji može predstavljati potencijalnu sekundarnu sirovinu za primjenu u stočnoj ishrani. U cilju procjene sigurnosti i potencijala primjene analiziranog materijala provedena su eksperimentalna laboratorijska ispitivanja koja su obuhvatila fizikalno-hemijske analize, mikrobiološka ispitivanja, FTIR spektroskopsku analizu te analizu sadržaja teških metala. Dobijeni rezultati fizikalno-hemijskih analiza ukazuju na stabilan mineralni sastav uzorka, dok mikrobiološka ispitivanja nisu pokazala prisustvo patogenih mikroorganizama. Analiza sadržaja teških metala pokazala je koncentracije ispod dozvoljenih granica propisanih relevantnim sigurnosnim standardima. FTIR analiza pokazali su da talog sadrži dominantan udio CaO (80,50%), što jasno potvrđuje prisustvo kalcijum-karbonata kao glavne komponente. Ovakav mineralni sastav ukazuje na potencijal taloga dase koristi kao izvor kalcijuma u stočnoj ishrani, budući da je $CaCO_3$ široko primjenjivan mineralni dodatak u industriji hrane za životinje. Dobijeni rezultati ukazuju da kontrolisana obrada i odgovarajuća tehnološka priprema nastalog taloga može predstavljati održivo rješenje u okviru cirkularnih proizvodnih sistema. Integracija islamskih etičkih principa sa savremenim konceptima cirkularne ekonomije može doprinijeti smanjenju otpada, efikasnijem korištenju resursa i razvoju održivih proizvodnih modela u skladu sa halal i tayyib standardima.

**Ključne riječi:** *cirkularna ekonomija, talog, israf, khalifa, mizan, tayyib, FTIR, teški metali, mikrobiologija, stočna hrana, halal*

**JOURNAL
OF HALAL QUALITY AND CERTIFICATION**

# HALALOPATHY: A SYSTEMS-BASED BRIDGE BETWEEN MODERN MEDICINE AND PROPHETIC MEDICINE

**Jawad Alzeer**

College of Medicine and Health Sciences, Palestine Polytechnic University, Hebron, Palestine,
Swiss Scientific Society for Developing Countries, Zürich, Switzerland

*Corresponding author: Jawad Alzeer*
*E-mail address: zeer@ppu.edu*

*Review paper*

## ABSTRACT

Modern medicine has achieved remarkable advances in diagnostics, pharmacology, and acute care; however, many chronic diseases remain closely linked to lifestyle, behavioral patterns, and psychosocial factors that extend beyond the conventional biomedical model. At the same time, traditional frameworks such as Prophetic medicine (Tibb al-Nabawi) have historically emphasized preventive health, moral conduct, dietary balance, and spiritual well-being. Despite their shared concern for human health, these two paradigms have largely evolved in parallel rather than in dialogue. This paper introduces Halalopathy, a conceptual framework that seeks to bridge modern biomedical science with the holistic principles embedded in Prophetic medicine. Halalopathy proposes that health emerges from the dynamic interaction between biological regulation, lifestyle behaviors, ethical conduct, and spiritual orientation. Drawing on concepts from systems medicine, psychoneuroimmunology, lifestyle medicine, and Islamic ethical traditions, the model interprets human health as a multidimensional balance in which behavioral choices, environmental exposures, and spiritual meaning influence physiological regulation and disease susceptibility. Within this framework, the concept of halal is expanded beyond its legal dimension to encompass a broader principle of purity, safety, and compatibility with human biological and moral integrity. Halalopathy therefore integrates preventive lifestyle practices—such as balanced nutrition, moderation, physical activity, emotional regulation, and spiritual mindfulness—with contemporary medical understanding of metabolic, neurological, and immune processes. By positioning Prophetic guidance within a systems-oriented biomedical perspective, Halalopathy provides a translational model that may help connect traditional wisdom with modern scientific approaches to health promotion and disease prevention. Further interdisciplinary research is needed to empirically investigate its mechanisms and clinical applications.

**Keywords:** *Halalopathy, Prophetic medicine, Tibb al-Nabawi, integrative medicine, lifestyle medicine, systems medicine, preventive medicine, Lifestylopathy.*

## Introduction

Modern medicine and Prophetic medicine are two important ways of understanding health, but they have developed largely separately. Both aim to prevent illness and improve well-being, yet they are based on different ways of thinking and different methods of knowledge. As health problems become more complex, especially with the rise of chronic diseases, there is a growing need to bring these perspectives together in a more meaningful and practical way.

Modern medicine is built on scientific methods such as observation, experimentation, and measurement. Its strength lies in its ability to identify specific biological causes of disease and treat them effectively. This has led to major advances in areas like surgery, medication, and emergency care. It works especially well in acute conditions—such as infections or injuries—where the cause is clear and treatment can be directly applied (Engel, 1977).

However, many of today's most common health problems are not simple or single-cause conditions. Diseases like diabetes, heart disease, and mental health disorders develop over time through a combination of biological, behavioral, environmental, and psychological factors. In these cases, focusing only on individual markers or symptoms may not fully address the deeper causes of illness. A person may appear clinically stable while still experiencing ongoing imbalance in other aspects of health (Sadiq, 2023).

Prophetic medicine (*Tibb al-Nabawi*) approaches health from a different angle. It views the human being as a connected whole, where physical health is closely linked to behavior, emotions, environment, and spiritual state. Within this perspective, health is not just the absence of disease, but a state of balance and harmony across these dimensions. Practices such as moderation in lifestyle, emotional control, cleanliness, and remembrance (*dhikr*) are seen as essential for maintaining this balance (Mogharbel et al., 2023).

Despite this broader view, Prophetic medicine is not usually presented in a structured scientific form. This makes it difficult to study, measure, or apply within modern clinical systems, even when its ideas align with current research in areas like stress, behavior, and lifestyle. As a result, it is often seen as separate from modern medicine rather than as a perspective that can complement it (Alrawi and Fetters, 2012).

This situation reveals a clear gap. Modern medicine offers precision and strong scientific tools, but sometimes overlooks the bigger system in which health develops. Prophetic medicine offers a comprehensive and meaningful view of human well-being, but lacks a shared scientific structure for analysis and application. While fields like lifestyle and integrative medicine try to bridge this gap, they often do not provide a clear system that connects biological processes with behavior, environment, and deeper human values (Koenig, 2012).

To address this, a more structured and integrative framework is needed—one that brings these perspectives together without reducing one to the other.

This paper introduces Halalopathy as a framework designed to bring these perspectives together (Hasan et al., 2026). It is not intended to replace modern medicine, but to complement it by offering a broader, systems-based way of understanding health. Halalopathy is a conceptual systems framework intended to guide hypothesis generation rather than provide experimentally validated mechanisms. In this view, health is not limited to biological function alone, but emerges from the interaction between physiology, lifestyle, environment, and value-based factors. Halalopathy provides a way to connect these elements through clear and meaningful relationships (Alzeer, 2026a).

## Epistemic Complementarity: Integrating Precision and Coherence

Modern medicine approaches health through a structured scientific method. It relies on observation, measurement, and analysis to identify specific biological changes in the body—whether at the level of organs, cells, or molecular processes. By linking these changes to disease, it allows for targeted interventions

such as medication, surgery, or other therapies. This approach is highly effective, particularly when the cause of a condition can be clearly identified and directly treated. However, because it focuses on measurable mechanisms, it may not always fully capture how long-term interactions—such as stress, lifestyle, and environment—gradually influence the overall condition of the system (Guyatt et al., 1992).

Prophetic medicine approaches health from a different angle. Rather than starting with isolated biological changes, it focuses on the internal state of the person, especially the presence of tranquility. In the Qur'anic description, this state is expressed as "no fear and no grief"—a condition of inner calm and stability. This is not only a spiritual idea, but also a meaningful indicator of balance within the system. When a person is in this state, both psychological and physiological processes tend to be more regulated. Stress responses are reduced, emotional stability is improved, and the body is better able to maintain its normal functions (Ghadirian, 2021).

From a Halalopathy perspective, these two approaches can be understood as addressing different aspects of the same system. Modern medicine focuses on identifying and reducing specific sources of dysfunction, which relates to lowering Entropy Load—the accumulation of stress and imbalance in the body (Alzeer, 2025a). Prophetic medicine, through the cultivation of tranquility, supports the system's Potential Energy—its ability to remain stable, adapt, and recover. The state of "no fear and no grief" can therefore be seen as a practical sign that the system is functioning in a balanced and regulated way (Alzeer, 2021).

Seen together, these approaches are not in conflict. Modern medicine provides the tools to detect and manage specific biological problems, while Prophetic medicine provides a way to understand and support the system's overall state of balance. When Entropy Load is reduced and tranquility is established, the system is better able to regulate itself and maintain health (Maizes et al., 2009).

Halalopathy brings these ideas together by framing health as a dynamic balance between Entropy Load and Potential Energy, with tranquility serving as a clear indicator of internal stability (Alzeer, 2019). In this view, biological processes and inner state are not separate, but closely connected parts of the same system. This creates a shared language through which biological, behavioral, environmental, and internal factors can be understood together. As a result, modern medicine and Prophetic medicine are not simply placed side by side, but are functionally integrated—each contributing to how balance is maintained or lost (Alzeer, 2024).

## Conceptual Foundations Supporting the Bridge

For Halalopathy to function as a meaningful bridge between modern medicine and Prophetic medicine, it requires a shared conceptual foundation. Rather than introducing a new framework, it builds on thermodynamics, a fundamental scientific model that applies to all living systems, including the human body (Alzeer, 2026b).

Thermodynamics describes how energy is used to maintain structure and function, and how systems naturally tend toward disorder over time. According to the Second Law of Thermodynamics, this drift toward disorder is inevitable unless energy is continuously supplied to sustain organization. In biological systems, this process is reflected in the ongoing demands placed on cells and regulatory networks—metabolic activity, stress responses, and continuous repair. Over time, these demands can reduce efficiency, disrupt coordination, and challenge the system's stability. In Halalopathy, this accumulated burden is described as Entropy Load (Alzeer, 2022a). Entropy Load is used here as a functional analogy, not a direct thermodynamic measurement, to describe the cumulative burden on the system.

At the same time, the body possesses inherent mechanisms that counter this process. It continuously regulates, repairs, and adapts in response to internal and external changes. This capacity can be understood as Potential Energy—the system's ability to maintain order, recover from stress, and preserve

function. Similarly, Potential Energy is used as a conceptual representation of the system's regulatory and adaptive capacity, rather than a direct physical quantity. From this perspective, health emerges not as a static condition, but as the result of a dynamic balance between Entropy Load and the system's available potential.

*Health as a Dynamic Balance*

Within this framework, health is best understood as an active and continuously regulated state, rather than a fixed condition. The human system is constantly adjusting to internal signals and external inputs, maintaining function through ongoing coordination. Minor fluctuations are expected and usually resolved through normal regulatory processes. However, when pressures persist or accumulate, the system's ability to maintain this coordination can gradually weaken.

This reflects a homeodynamic view of health, where stability is achieved through continuous adaptation rather than static equilibrium. The system remains functional not by resisting change, but by responding to it in a controlled and organized way (Alzeer, 2023a).

A key feature of this regulation is the principle of duality, expressed through complementary processes. Biological systems operate through paired dynamics—such as activation and recovery, excitation and inhibition, and repair and breakdown. These are not opposing failures, but essential and coordinated cycles that sustain function. Health depends on the system's ability to move between these states appropriately, without becoming fixed or imbalanced in either direction.

In Halalopathy, this regulatory behavior is understood through the interaction between Entropy Load and Potential Energy. Entropy reflects the ongoing demands placed on the system, while potential represents its capacity to maintain structure and respond effectively. Health is maintained when this relationship remains balanced, allowing the system to function, adapt, and recover over time.

*Entropy Load: The Accumulation of System Burden*

Entropy Load refers to the total demand placed on the system over time. It does not arise from a single source, but from the combined effect of multiple influences acting together. These may include ongoing physiological stress, metabolic imbalance, environmental challenges, and sustained psychological pressure.

The key issue is not simply the presence of these influences, but how they accumulate and interact. While the system can adapt to short-term demands, persistent and overlapping pressures gradually increase the overall burden. As this burden grows, coordination between biological processes becomes less efficient, and regulation begins to weaken. This gradual shift helps explain why many chronic conditions develop over time, as the system moves away from stable function under sustained load (Alzeer and Benmerabet, 2023).

*Potential Energy: The System's Capacity for Stability and Recovery*

In contrast to Entropy Load, Potential Energy represents the system's available capacity to maintain structure and function. It reflects the combined strength of internal processes that support regulation, repair, and adaptation.

This capacity is not located in a single component, but emerges from the coordinated activity of multiple systems. From a conventional scientific perspective, these include biological, functional, and psychological processes. Within the Halalopathy framework, this capacity can be further understood as arising from four interrelated domains of potential: chemical, physical, mental, and voluntary. Together, these domains describe the system's ability to sustain order, respond to stress, and maintain coherence over time (Alzeer et al., 2025).

*The Immune System: A Window into System Balance*

Within this framework, the immune system serves as a sensitive indicator of the system's internal state. Its behavior reflects

how well the body is maintaining balance between Entropy Load and Potential Energy, responding not only to physical inputs, but also to psychological conditions.

This behavior can be understood through three functional modes. These modes are not intended as discrete immunological categories, but as functional system-level states that align with established concepts in stress physiology and neuroimmune regulation. In particular, they can be interpreted in relation to allostatic load (McEwen, 1998), where prolonged stress alters immune function, as well as shifts in autonomic balance between sympathetic activation and parasympathetic recovery, which are known to influence inflammatory and regulatory pathways.

In its balanced state, the system may operate in a tranquil fight mode, corresponding to a condition of "no fear and no grief." In this state, the immune response is relatively well-regulated, able to activate when needed and return smoothly to recovery. Physiological processes remain coordinated, and psychological stability supports efficient regulation. This state is consistent with balanced autonomic activity, where sympathetic activation and parasympathetic recovery are appropriately aligned, supporting effective neuroendocrine and immune function. The system is therefore both responsive and stable, maintaining function without excessive strain (Alzeer, 2022b).

When Entropy Load becomes elevated and unresolved, the system may shift into fright mode, where fear begins to dominate. In this condition, activation becomes prolonged, and the immune system remains in a heightened state of alert. Inflammatory activity may increase, and regulatory precision becomes reduced, leading to responses that are amplified or sustained beyond what is necessary. This pattern is consistent with increased allostatic load and sustained sympathetic activation, both of which are associated with dysregulated immune responses and chronic inflammatory conditions (McEwen, 1998).

On the other hand, when the system's Potential Energy is reduced, it may enter flight mode, where grief and withdrawal predominate. In this state, responsiveness declines, recovery slows, and the system shifts toward energy conservation rather than active engagement. This condition may reflect reduced physiological resilience and altered neuroimmune signaling, sometimes associated with chronic stress, fatigue, or exhaustion-related states. As a result, the system's ability to respond effectively to challenges becomes diminished.

These three modes—tranquil fight, fright, and flight—highlight that immune function is not simply active or inactive, but continuously adapting to the overall condition of the system. The presence of tranquility reflects balance, while fear and grief signal different forms of imbalance, each affecting how the body regulates and responds over time (Alzeer et al., 2025).

*Compatibility (Halal Tayyib): Maintaining System Integrity*

An important principle within this framework is compatibility, expressed through the concept of Halal Tayyib. Here, it refers to the degree to which any input aligns with the system's natural requirements and supports its overall stability.
The system is continuously influenced by what it receives-through nutrition, behavior, environment, and internal states. When these inputs are compatible, they support efficient function, preserve internal capacity, and help maintain balance. When they are not, even in subtle ways, they can introduce friction into the system, gradually increasing Entropy Load and reducing its ability to regulate effectively.

This principle extends across different aspects of life, including what we consume, how we act, and how our choices align with our values and intentions. Over time, consistent alignment supports stability, while repeated mismatch contributes to imbalance and loss of coherence within the system.

*The Seven Levers of Health*

To translate this framework into practice, Halalopathy identifies seven primary domains through which the system is continuously regulated: nutrition, breathing, movement,

sleep, psychological state, environment, and spiritual alignment.

Each of these domains is supported by established physiological mechanisms. For example, sleep plays a central role in circadian rhythm regulation, which influences hormonal balance, immune function, and metabolic processes (Besedovsky et al., 2012). Movement contributes to metabolic regulation, mitochondrial function, and cardiovascular health (Holloszy, 2008). Breathing patterns are closely linked to autonomic regulation, where slow and controlled breathing can enhance vagal tone and support parasympathetic activity (Gerritsen and Band, 2018). Similarly, nutrition provides the biochemical substrates required for cellular function and repair, while psychological state influences neuroendocrine signaling and stress responses (Lee and Dixit, 2020). The environment shapes exposure to physical and social stressors, and spiritual alignment, within this framework, may contribute to psychological stability and reduced stress reactivity. Together, these domains reflect interconnected pathways through which lifestyle and internal state influence system regulation.

Because of this interconnected structure, system stability depends on the combined influence of multiple domains rather than isolated factors. As a result, meaningful and sustained improvement is more likely when these areas are addressed in a coordinated way, allowing the system to restore balance more effectively.

*Synthesis: A Unified View of Health*

Bringing these elements together, Halalopathy understands health as a dynamic balance between Entropy Load and Potential Energy, where stability depends on the system's ability to manage accumulated demands while preserving its capacity for regulation and recovery. Disease arises when this balance is disrupted-when the burden exceeds what the system can effectively handle-while healing involves both reducing that burden and restoring the system's internal capacity.

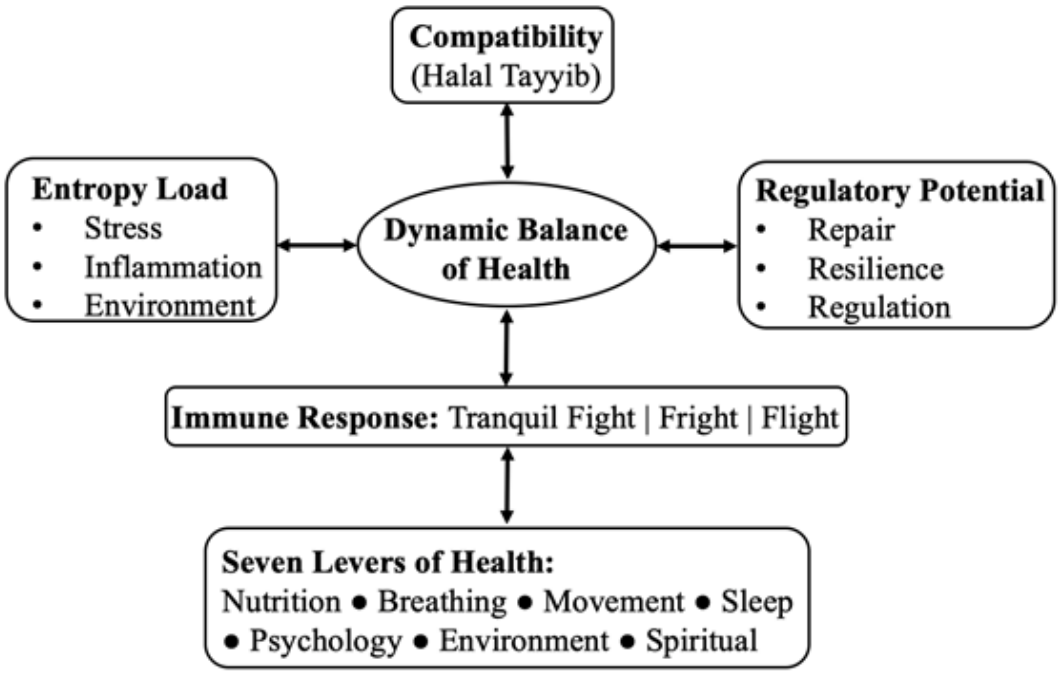


Figure 1: Halalopathy conceptualizes health as a dynamic balance between Entropy Load and regulatory potential.

By grounding this view in thermodynamics, the framework offers a common scientific language that connects biological processes with behavior, environment, and internal state. At the same time, it provides a structured way to interpret principles emphasized in Prophetic

medicine—such as balance, moderation, and alignment—within a coherent and analyzable model (See Figure 1). Although many of these ideas, including stress accumulation, resilience, and system regulation, have been explored in different contexts, Halalopathy integrates them into a single, consistent framework that supports a more complete understanding of health, disease, and recovery.

**From Treatment to Healing: Reframing Cure Across Paradigms**

A key difference between modern medicine and Prophetic medicine lies in how each understands treatment and healing. While modern medicine focuses on identifying and correcting specific biological dysfunctions, Prophetic medicine places greater emphasis on the conditions that allow healing to occur. Halalopathy brings these perspectives together by viewing healing as a process of restoring balance within the system, rather than as a single intervention or outcome (Egnew, 2005).

Modern medicine provides effective tools for managing disease, especially when causes are clear and measurable. It allows for targeted interventions that can stabilize or correct specific abnormalities. However, in many chronic conditions, improvement at the level of measurable indicators does not always translate into full recovery. From a systems perspective, this reflects a situation where Entropy Load remains elevated, even if certain symptoms are controlled (A'aqoulah et al., 2025).

Prophetic medicine approaches this differently by emphasizing that healing ultimately comes from Allah, while human effort is directed toward managing the process and creating the right conditions. As expressed in the Qur'an: "And when I am ill, it is He who heals me." (Qur'an 26:80).

This principle does not negate the role of treatment, but places it within a broader understanding. Human actions—whether medical, behavioral, or environmental—serve as means, but they do not act independently. Healing occurs when the system is aligned in a way that allows restoration to take place.

The Qur'an presents healing as a multi-dimensional process, involving both physical and non-physical inputs. For example, it refers to natural substances with therapeutic value: "From their bellies comes a drink of varying colors, in which there is healing for people." (Qur'an 16:69)

This can be understood as representing material intervention, similar to medicine. At the same time, the Qur'an emphasizes the role of guidance and beneficial input: "O mankind, there has come to you an instruction from your Lord and a healing for what is in the hearts…" (Qur'an 10:57)

Here, healing is linked to meaning, guidance, and inner state, which influence both psychological and physiological regulation. The Qur'an also highlights the importance of choosing what is good (*Tayyib*) and avoiding what is harmful (*Khabith*), not only in what is consumed, but in behavior and speech: "Allah presents an example: a good word is like a good tree… and a bad word is like a bad tree…"(Qur'an 14:24–26)

This reflects how inputs—whether physical or cognitive—can either support the system's stability or contribute to its disruption.

In addition, the Qur'an itself is described as a source of healing: "And We send down from the Qur'an that which is healing and mercy…" (Qur'an 17:82)

From a Halalopathy perspective, this can be understood as influencing the system through tranquility, regulation, and reduction of internal stress, which supports the system's Potential Energy and overall stability.

Taken together, these elements suggest that healing is not the result of a single factor, but of a coordinated combination of inputs—material treatment, beneficial guidance, compatible lifestyle, and spiritual alignment. When these are present together, they create a form of synergy, where the overall effect is greater than any single intervention alone.

Halalopathy interprets this as a process in which Entropy Load is reduced from multiple directions, while Potential Energy is

strengthened across different domains. In this integrated state, the system becomes more capable of regulating itself, allowing recovery to move beyond symptom control toward more complete restoration.

In this way, healing is understood not simply as the removal of disease, but as the emergence of balance within the system, supported by both scientific intervention and meaningful alignment.

**Illustrative Qur'anic Case: Prophet Ayyub (AS)**

To understand how Halalopathy can be applied in practice, the story of Prophet Ayyub (AS) offers a powerful and meaningful example. While the account in the Qur'an is primarily spiritual, it can also be carefully understood as a model that reflects how the human system responds to prolonged stress, maintains stability, and moves toward recovery. The purpose here is not to treat it as a clinical case, but to use it as a conceptual illustration of how balance and healing can emerge within a complex system. This interpretation is heuristic and not intended as historical or clinical evidence.

The Qur'an describes that Prophet Ayyub (AS) experienced a long period of hardship affecting his health, environment, and overall condition. From a systems perspective, this represents a state of sustained high Entropy Load, where multiple pressures act simultaneously. What is particularly notable is that, despite this external burden, his internal state remained stable. He maintained patience and trust, without internal collapse or conflict.

Within Halalopathy, this distinction is essential. It shows that even under significant external strain, the system's Potential Energy can be preserved, especially through emotional stability, meaning, and coherence. This aligns with modern understanding: stable psychological states are associated with more balanced neuroendocrine signaling, improved immune regulation, and reduced chronic stress activation (McEwen, 1998).

A turning point appears in a brief but profound supplication: "Indeed, adversity has touched me, and You are the Most Merciful of the merciful." (Qur'an 21:83)

This moment reflects a shift from resistance to alignment. Rather than rejecting the condition, it integrates awareness with trust. From a systems perspective, this reduces internally generated stress, thereby lowering part of the Entropy Load, while reinforcing coherence and preserving Potential Energy.

Following this internal realignment, the Qur'an introduces a specific intervention: "Strike [the ground] with your foot; this is a cool washing place and a drink." (Qur'an 38:42)

This intervention involves water used both externally and internally, which can be understood through a scientific lens as a form of thermoregulatory and hydration-based therapy.

From a physiological perspective, water plays a critical role in maintaining thermal and metabolic balance. Internally, adequate hydration supports circulation, cellular function, and metabolic efficiency, helping the body manage biochemical stress. It also facilitates the removal of metabolic byproducts, which contributes to reducing systemic burden (Jéquier and Constant, 2010).

Externally, the use of cool water introduces an important mechanism of heat transfer and thermal regulation (Gleeson, 1998). The human body constantly produces heat as a byproduct of metabolism and stress responses. Excess heat can be understood as a contributor to entropy, reflecting increased system activity and strain. Water, due to its high specific heat capacity, is highly effective at absorbing heat. When applied externally—especially in a cool state—it draws heat away from the body through conduction, helping to reduce thermal load and restore physiological balance. This process is similar to what is described in modern terms as hydrotherapy or thermoregulatory cooling, where external cooling supports internal stabilization (Mooventhan and Niyithitha, 2014).

The combined internal and external use of water, therefore, can be seen as a coordinated

intervention that may reduce Entropy Load by improving hydration, supporting metabolic processes, and facilitating heat dissipation.

However, the significance of this intervention is not only in its physical effect, but in its precision and compatibility. It is simple, but exactly suited to the condition of the system at that moment. It does not introduce additional stress, but instead supports recovery in a targeted way.

When viewed together, the sequence in this narrative reflects a coordinated process of healing:

- Preservation of internal stability (limiting internal entropy)
- Alignment through meaning and trust (supporting Potential Energy)
- A compatible and context-specific intervention (reducing systemic burden)
- Timely action aligned with the system's condition

As Entropy Load is reduced through this coordinated process, the system is able to shift toward a more regulated state. In Halalopathy terms, this allows the immune system to operate in its tranquil fight mode—a balanced condition of activation and recovery—thereby supporting effective repair and contributing to more complete recovery (Alzeer, 2025b).

This combination leads to a shift from overload toward recovery. In Halalopathy terms, it represents a rebalancing between Entropy Load and Potential Energy, allowing the system to regain stability and function.

It is important to emphasize that this intervention is specific to the condition of Prophet Ayyub (AS) and should not be generalized as a universal treatment. The Qur'an presents different responses for different conditions. For example, the experience of Prophet Yunus (AS) involves a different form of restoration, reflecting a different state and therefore a different pathway to recovery (Alzeer, 2025c).

This highlights an important principle: healing is not uniform—it is contextual and individualized. Effective therapy must be compatible with the specific condition of the system. The Qur'anic approach, in this sense, reflects a form of personalized intervention, where the type of input is matched to the nature of the imbalance (Alzeer, 2023b).

Through the lens of Halalopathy, the story of Prophet Ayyub (AS) demonstrates that recovery is not driven by a single factor, but by the alignment of internal state, appropriate intervention, and contextual understanding. Complete healing emerges when the right inputs are applied in the right way, at the right time, in accordance with the system's needs.

**Conclusion**

Halalopathy offers a systems-based framework for understanding health, disease, and recovery through the interaction between Entropy Load and Potential Energy. Rather than viewing illness only as an isolated biological abnormality, it interprets disease as a state in which accumulated burdens exceed the system's capacity to regulate, repair, and maintain balance. In this model, healing involves more than symptom control; it requires reducing the sources of systemic pressure while strengthening the internal capacity for stability and recovery.

The value of Halalopathy lies in its ability to connect modern biomedical science with the broader principles emphasized in Prophetic medicine. Modern medicine contributes precision, measurement, and targeted intervention, while Prophetic medicine contributes a wider understanding of balance, tranquility, compatibility, and spiritual alignment. Through this integration, Halalopathy provides a shared language in which biological, behavioral, environmental, psychological, and spiritual inputs can be understood as interacting parts of one living system.

The immune system is especially important within this framework because it reflects the internal state of the organism. When Entropy Load is reduced and Potential Energy is preserved, immune regulation may shift toward a more balanced and restorative mode. The Qur'anic account of Prophet Ayyub (AS) illustrates this principle through the alignment of internal stability, compatible therapy, and personalized intervention.

Halalopathy should not be understood as an alternative to modern medicine, but as

a complementary framework that broadens the meaning of healing. Its future value will depend on careful scientific development, clear definitions, and practical tools that allow its concepts to be studied and applied responsibly.

## References


A'aqoulah, A., El-Metwally, A. A., Al Khateeb, B., Alammari, D., Alshahrani, A., Aldubikhi, A., Alsulami, A., Fatani, F. and Innab, N. (2025), "Challenges and opportunities of complexity theory in health care systems", *Journal of Taibah University Medical Sciences*, Vol. 20 No. 4, pp. 429–434. https://doi.org/10.1016/j.jtumed.2025.06.006.

Alrawi, S. N. and Fetters, M. D. (2012), "Traditional arabic & islamic medicine: a conceptual model for clinicians and researchers", *Global Journal of Health Science*, Vol. 4 No. 3, pp. 164–169. https://doi.org/10.5539/gjhs.v4n3p164.

Alzeer, J. (2018), "Halalopathic: A New Concept in Medicine", *Journal of Molecular and Genetic Medicine*, Vol. 12 No. 2, p. 353. https://doi.org/10.4172/1747-0862.1000353.

Alzeer, J. (2019), "Halalopathy: A science of trust in medicine", *Journal of Integrative Medicine*, Vol. 17 No. 3, pp. 150–154. https://doi.org/10.1016/j.joim.2019.03.005.

Alzeer, J. (2021), "Permissible medicine and rationalization of halal pharma", *Halalsphere*, Vol. 1 No. 1, pp. 43–52. https://doi.org/10.31436/hs.v1i1.18.

Alzeer, J. (2022a), "Halalopathy: Improving Potential Energy and minimizing entropy offer an integrative approach for more effective treatment", *Medical Case Reports and Study*, Vol. 3 No. 2. https://doi.org/10.55162/mcms.02.027.

Alzeer, J. (2022b), "Halalopathy: Stimulation of the immune system through enrichment of Potential Energy", *International Journal of Regenerative Medicine*, pp. 1–5. https://doi.org/10.31487/j.rgm.2022.01.02.

Alzeer, J. (2023a), "Lifestylopathy: Unlocking potential by embracing duality and homeostasis for improved healthcare", *International Journal of Regenerative Medicine*, pp. 1–6. https://doi.org/10.31487/j.rgm.2023.02.02.

Alzeer, J. (2023b), "Integrating medicine with lifestyle for personalized and holistic healthcare", *Journal of Public Health and Emergency*, Vol. 7, p. 33. https://doi.org/10.21037/jphe-23-71.

Alzeer, J. (2024), "Holistic approach to personalised medicine: A focus on halalopathy", *Halalsphere*, Vol. 4 No. 2, pp. 22–28. https://doi.org/10.31436/hs.v4i2.97.

Alzeer, J. (2025a), "Halalopathy and Lifestylopathy: Integrating Ethical and Scientific Principles in Personalized Medicine", *Journal of Halal Quality and Certification*, Vol. 3 No. 1, pp. 69–79. https://hrcak.srce.hr/en/file/482370.

Alzeer, J. (2025b), "Lifestylopathy and ethical pharmaceuticals: A Halalopathy perspective", *Medical Research Archives*, Vol. 13 No. 3. https://doi.org/10.18103/mra.v13i3.6384.

Alzeer, J. (2025c), "Personalized health through epigenetics: The Lifestylopathy approach", *Medical Research Archives*, Vol. 13 No. 4. https://doi.org/10.18103/mra.v13i4.6435.

Alzeer, J. (2026a), "Halalopathy: Integrating Traditional Healing and Modern Medicine for Holistic Healthcare", in Hasan, Q., Alzeer, J., Ja'afar, F. and Tamiya, E. (Eds), *Halal Perspectives in Medicinal Chemistry*, Springer, Singapore, pp. [Insert Page Range]. https://doi.org/10.1007/978-981-95-6378-4_7.

Alzeer, J. (2026b), "Small-Molecule Drug Discovery: Evolution of Medicinal Chemistry and Holistic Approaches", in Hasan, Q., Alzeer, J., Ja'afar, F. and Tamiya, E. (Eds), *Halal Perspectives in Medicinal Chemistry*, Springer, Singapore, pp. [Insert Page Range]. https://doi.org/10.1007/978-981-95-6378-4_6.

Alzeer, J. and Benmerabet, H. (2023), "The development of human personality: A comprehensive overview", *Psychological Disorders and Research*, pp. 1–8. https://doi.org/10.31487/j.pdr.2023.01.01.

Alzeer, J., Ahmad, J., Meshal, T., Salloum, O. and Seder, M. (2025), "Lifestylopathy: A thermodynamic framework for immune regulation and health restoration", *Medical Research Archives*, Vol. 13 No. 7. https://doi.org/10.18103/mra.v13i7.6774.

Besedovsky, L., Lange, T. and Born, J. (2012), "Sleep and immune function", Pflügers Archiv - European Journal of Physiology, Vol. 463 No. 1, pp. 121–137. https://doi.org/10.1007/s00424-011-1044-0.

Egnew, T. R. (2005), "The meaning of healing: transcending suffering", *Annals of Family Medicine*, Vol. 3 No. 3, pp. 255–262. https://doi.org/10.1370/afm.313.

Engel, G. L. (1977), "The need for a new medical model: a challenge for biomedicine", *Science*, Vol. 196 No. 4286, pp. 129–136. https://doi.org/10.1126/science.847460.

Gerritsen, R. J. and Band, G. P. (2018), "Breath of life: The respiratory vagal stimulation model of contemplative activity", Frontiers in Human Neuroscience, Vol. 12, Art. 397. https://doi.org/10.3389/fnhum.2018.00397.

Ghadirian, A. M. (2021), "The Role of Religion and Spirituality in Mental Health", in Okpaku,

S. O. (Ed), *Innovations in Global Mental Health*, Springer, Cham. https://doi.org/10.1007/978-3-030-57296-9_118.

Gleeson, M. (1998), "Temperature regulation during exercise", *International Journal of Sports Medicine*, Vol. 19 No. S2, pp. S96–S99. https://doi.org/10.1055/s-2007-971967.

Guyatt, G., Cairns, J., Churchill, D., Cook, D., Haynes, B., Hirsh, J. and Sackett, D. (1992), "Evidence-based medicine: a new approach to teaching the practice of medicine", *JAMA*, Vol. 268 No. 17, pp. 2420–2425. https://doi.org/10.1001/jama.1992.03490170092032.

Hasan, Q., Alzeer, J., Ja'afar, F. and Tamiya, E. (Eds) (2026), *Halal Perspectives in Medicinal Chemistry*, Springer, Singapore. https://doi.org/10.1007/978-981-95-6378-4.

Holloszy, J. O. (2008), "Regulation by exercise of skeletal muscle content of mitochondria and GLUT4", Journal of Physiology and Pharmacology, Vol. 59 Suppl 7, pp. 5–18.

Jéquier, E. and Constant, F. (2010), "Water as an essential nutrient: the physiological basis of hydration", *European Journal of Clinical Nutrition*, Vol. 64 No. 2, pp. 115–123. https://doi.org/10.1038/ejcn.2009.111.

Koenig, H. G. (2012), "Religion, spirituality, and health: the research and clinical implications", *ISRN Psychiatry*, Vol. 2012, Art. 278730. https://doi.org/10.5402/2012/278730.

Lee, A. C. and Dixit, V. D. (2020), "Dietary regulation of immunity", Immunity, Vol. 53 No. 3, pp. 510–523. https://doi.org/10.1016/j.immuni.2020.08.013.

Maizes, V., Rakel, D. and Niemiec, C. (2009), "Integrative medicine and patient-centered care", *Explore*, Vol. 5 No. 5, pp. 277–289. https://doi.org/10.1016/j.explore.2009.06.008.

McEwen, B. S. (1998), "Protective and damaging effects of stress mediators", *New England Journal of Medicine*, Vol. 338 No. 3, pp. 171–179. https://doi.org/10.1056/NEJM199801153380307.

Mogharbel, G. H., Badawi, A. S., Zaman, A. Y., Abd Elmoniem, M. M., Abdel-Rahman, I. M., Alenazi, M. E., Shah, F. A., Aly, M. A., Imam, S. N., Alenazi, N. E. and El Sayed, S. M. (2023), "Therapeutic benefits of prophetic medicine remedies in treating hematological diseases (A review article)", *American Journal of Blood Research*, Vol. 13 No. 4, pp. 130–142.

Mooventhan, A. and Nivethitha, L. (2014), "Scientific evidence-based effects of hydrotherapy on various systems of the body", *North American Journal of Medical Sciences*, Vol. 6 No. 5, pp. 199–209. https://doi.org/10.4103/1947-2714.132935.

Sadiq, I. Z. (2023), "Lifestyle medicine as a modality for prevention and management of chronic diseases", *Journal of Taibah University Medical Sciences*, Vol. 18 No. 5, pp. 1115–1117. https://doi.org/10.1016/j.jtumed.2023.04.001.

# HALALOPATIJA: SISTEMSKI MOST IZMEĐU SAVREMENE MEDICINE I POSLANIČKE MEDICINE

**Jawad Alzeer**

Fakultet medicine i zdravstvenih nauka, Palestinski politehnički univerzitet, Hebron, Palestina,
Švicarsko naučno društvo za zemlje u razvoju, Cirih, Švicarska.

*Autor za korespodenciju: Jawad Alzeer*
*E-mail adresa: zeer@ppu.edu*

## SAŽETAK

Savremena medicina postigla je izuzetne napretke u dijagnostici, farmakologiji i akutnoj njezi; međutim, mnoge hronične bolesti i dalje su usko povezane sa stilom života, obrascima ponašanja i psihosocijalnim faktorima koji prevazilaze klasični biomedicinski model. Istovremeno, tradicionalni okviri poput poslaničke medicine (Tibb al-Nabawi) historijski su naglašavali preventivno zdravlje, moralno ponašanje, uravnoteženu ishranu i duhovno blagostanje. Uprkos zajedničkoj brizi za ljudsko zdravlje, ova dva pristupa su se uglavnom razvijala paralelno, bez značajnog međusobnog dijaloga. Ovaj rad uvodi Halalopatiju, konceptualni okvir koji nastoji povezati savremenu biomedicinsku nauku s holističkim principima sadržanim u poslaničkoj medicini. Halalopatija predlaže da zdravlje nastaje kroz dinamičku interakciju biološke regulacije, životnih navika, etičkog ponašanja i duhovne orijentacije. Oslanjajući se na koncepte sistemske medicine, psihoneuroimunologije, medicine životnog stila i islamske etičke tradicije, ovaj model tumači ljudsko zdravlje kao višedimenzionalnu ravnotežu u kojoj ponašajne odluke, okolišni faktori i duhovni smisao utiču na fiziološku regulaciju i podložnost bolesti. U ovom okviru, pojam halal se proširuje izvan svoje pravne dimenzije i obuhvata širi princip čistoće, sigurnosti i usklađenosti s ljudskim biološkim i moralnim integritetom. Halalopatija stoga integriše preventivne životne prakse — poput uravnotežene ishrane, umjerenosti, fizičke aktivnosti, emocionalne regulacije i duhovne svjesnosti — s savremenim medicinskim razumijevanjem metaboličkih, neuroloških i imunoloških procesa. Pozicioniranjem poslaničkog učenja unutar sistemski orijentisanog biomedicinskog okvira, Halalopatija nudi translacijski model koji može pomoći u povezivanju tradicionalne mudrosti s modernim naučnim pristupima promociji zdravlja i prevenciji bolesti. Potrebna su dalja interdisciplinarna istraživanja kako bi se empirijski ispitali njeni mehanizmi i kliničke primjene.

**Kjučne riječi:** *Halalopatija, Poslanička medicina, Tibb al-Nabawi (Poslanička medicina), integrativna medicina, medicina životnog stila, sistemska medicina, preventivna medicina, lifestylopatija.*

**JOURNAL
OF HALAL QUALITY AND CERTIFICATION**

# ENHANCING HALAL COMPLIANCE THROUGH ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

**Aldijana Omerović[1], Azra Sinanović[1], Ragib Spahić[2],**

[1]University FINRA Tuzla, Faculty of Technical Science, Mitra Trifunovića Uče 9, 75000 Tuzla, Bosnia and Herzegovina
[2]Iffco Velvet doo, Hasana Merdžanovića 42, 71320 Vogošća, Bosnia and Herzegovina

*Corresponding author: Aldijana Omerović*
*E-mail address: aldijana.finra@gmail.com;*

*Review paper*

## ABSTRACT

The increasing demand for halal-certified products has created a need for more efficient and reliable verification systems. Traditional halal compliance processes rely on manual inspections and laboratory testing, which may be time-consuming and prone to human error. This study proposes an integrated approach based on Artificial Intelligence (AI) and Information Technology (IT) systems to enhance halal compliance. A machine learning classification model based on the Random Forest algorithm was developed using ingredient data from a labeled dataset. The model was trained to classify products into halal and non-compliant categories. Additionally, an IT-based framework was proposed to support data management and traceability. The experimental results show that the model achieved an accuracy of 96%, with high precision and recall values. These findings demonstrate that AI-based systems can significantly improve the efficiency, accuracy and reliability of halal verification processes.

**Keywords:** *halal compliance, artificial intelligence, machine learning, traceability, food classification*

## Introduction

The global halal food market has undergone substantial expansion in recent years, largely driven by increasing consumer awareness and demand for products that comply with religious and ethical standards. Ensuring halal compliance, however, remains a complex and multidimensional task, requiring rigorous verification of ingredients, production processes and supply chain integrity. Conventional approaches to halal certification are predominantly based on manual inspection and laboratory analysis. While these methods are well-established, they are often time-intensive, operationally demanding and susceptible to human error, particularly within increasingly complex and globalized supply networks. A considerable body of literature has highlighted the critical role of transparency and quality assurance in maintaining the credibility of halal certification systems. Bonne and Verbeke (2008) describe halal quality as a credence attribute, emphasizing the necessity for strict monitoring and control mechanisms throughout the supply chain. In a similar vein, Wilson and Liu (2010) underscore the importance of trust and traceability as fundamental determinants

of consumer confidence in halal products, particularly in markets characterized by information asymmetry. In response to these challenges, recent research has explored the integration of advanced technological solutions into food verification systems. Tian (2017) demonstrates that blockchain-based frameworks can significantly enhance traceability and ensure data integrity within food supply chains by providing immutable and transparent records. Similar approaches have been discussed by Iftekhar et al. (2021) and Casino et al. (2019), who emphasize the role of digital technologies in improving transparency and safety in food systems. Moreover, Jiang et al. (2017) highlight the broader potential of artificial intelligence in improving data-driven decision-making processes, suggesting its applicability in domains such as food safety and certification. Building upon these technological developments, machine learning has emerged as a particularly promising approach for addressing the inherent complexity of food classification problems. Unlike traditional rule-based systems, machine learning models are capable of learning from labeled datasets and generalizing this knowledge to previously unseen instances. In the context of halal compliance, this capability enables the automated analysis of ingredient compositions and facilitates the early identification of potentially non-compliant products, thereby enhancing both efficiency and reliability. Among the various machine learning techniques, ensemble-based methods such as the Random Forest algorithm have demonstrated robust performance in classification tasks. Random Forest operates by generating multiple decision trees during the training phase and aggregating their predictions, thereby improving overall accuracy and reducing the likelihood of overfitting (Breiman, 2001). This approach is particularly well-suited for handling high-dimensional data derived from textual sources, such as ingredient lists transformed into numerical feature representations. In this study, the Random Forest model is employed to classify food products based on ingredient data, enabling the identification of patterns associated with halal and non-compliant categories. Despite the growing interest in technological applications within food systems, the existing literature remains largely focused on general food safety, traceability and halal certification from regulatory or marketing perspectives. The integration of Artificial Intelligence and IT systems specifically for halal compliance analysis remains relatively underexplored. This gap is even more pronounced in the context of Bosnia and Herzegovina, where research efforts have predominantly addressed halal standards, certification frameworks and consumer behavior, with limited emphasis on the application of advanced analytical and computational methods. Accordingly, there is a clear need for research that bridges this gap by introducing data-driven approaches to halal verification. The present study aims to contribute to this emerging field by proposing and evaluating an AI-based classification model for halal compliance, supported by an IT-based framework for structured data management and traceability. This integrated approach seeks to enhance the efficiency, transparency and reliability of halal certification processes in contemporary food systems.

## Materials and Methods

The experimental analysis conducted in this study is based on a supervised machine learning approach applied to a publicly available dataset, namely the Food Ingredients Dataset with Halal Label, obtained from the Kaggle platform. This dataset contains textual descriptions of food product ingredients along with corresponding classification labels indicating whether the product is halal-compliant or non-compliant. Such a structure makes the dataset particularly suitable for classification tasks, as it enables the model to learn the relationship between ingredient composition and compliance status. The dataset comprises a diverse set of food products with varying ingredient formulations, reflecting real-world complexity in food production. The primary variable used in the analysis is the ingredient text, while the target variable represents the assigned class label. This setup allows the investigation of how ingredient-level information can be used to predict halal compliance through data-driven methods. Prior to model development, a preprocessing phase was carried out to ensure data quality and

consistency. This phase included the removal of missing or incomplete entries, normalization of textual data (e.g., conversion to lowercase and standardization of ingredient expressions), and preparation of the dataset for machine learning processing. Since the input data are in textual form, a transformation into numerical representation was required. For this purpose, a bag-of-words approach was employed, which converts textual ingredient descriptions into a structured matrix of token frequencies, enabling their use as input features for classification algorithms. For this purpose, a bag-of-words approach was employed, which converts textual data into a structured numerical representation suitable for machine learning algorithms (Zhang et al., 2010). A supervised machine learning model was developed using the Random Forest algorithm. This algorithm was selected due to its robustness, high classification performance and suitability for handling high-dimensional data derived from text. Random Forest operates by constructing an ensemble of decision trees during the training phase and aggregating their outputs, thereby improving prediction accuracy and reducing overfitting (Breiman, 2001). This ensemble approach improves generalization capability and reduces the risk of overfitting, which is particularly important when dealing with complex and heterogeneous datasets such as food ingredient data.

To evaluate the performance of the model, the dataset was divided into two subsets: a training set (70%) and a testing set (30%). The training set was used to build and optimize the model, while the testing set was used to assess its predictive performance on previously unseen data. This approach ensures an objective evaluation of the model's generalization ability. Model performance was assessed using standard classification metrics, including accuracy, precision, recall and F1-score. Accuracy provides an overall measure of correct classifications, while precision and recall offer insights into the model's performance across individual classes. The F1-score, as a harmonic mean of precision and recall, provides a balanced measure of classification quality, particularly in cases where class distribution may vary. In addition to the machine learning component, this study proposes an IT-based framework to support data management and traceability in halal compliance verification. The proposed system integrates data storage, preprocessing and classification functionalities within a unified structure. Ingredient and product data are stored in a centralized database, processed through a data preparation module, and subsequently analyzed using the trained AI model. The system is designed to provide real-time classification outputs, thereby enabling faster and more efficient decision-making in halal verification processes. The experimental implementation was carried out in a Python-based data analysis environment using Jupyter Notebook, which enabled efficient data exploration, preprocessing and model evaluation. The Pandas library was used for data handling, while Scikit-learn was applied for the development and evaluation of the machine learning model.

## Results and Discussion

Table 1 presents the distribution of the dataset used in this study. The dataset consists of 39,787 food product samples categorized into halal and non-compliant classes. The distribution shows a relatively balanced dataset, with 54.86% halal and 45.14% non-compliant products. This balance is important for ensuring that the machine learning model does not become biased toward a specific class and can achieve reliable classification performance.

**Table 1** Dataset distribution

| **Category** | **Number of samples** | **Percentage** |
|---|---|---|
| Halal | 21,826 | 54.86% |
| Non-compliant | 17,961 | 45.14% |
| **Total** | 39,787 | 100% |

The distribution of classes in the dataset indicates a moderately balanced representation of halal and non-compliant products, which supports effective model training and evaluation.

The performance of the proposed machine learning model was evaluated using standard classification metrics, including accuracy, precision, recall and F1-score. The results indicate that the Random Forest model achieved an overall accuracy of 96%, demonstrating

a high level of reliability in classifying food products based on ingredient composition.

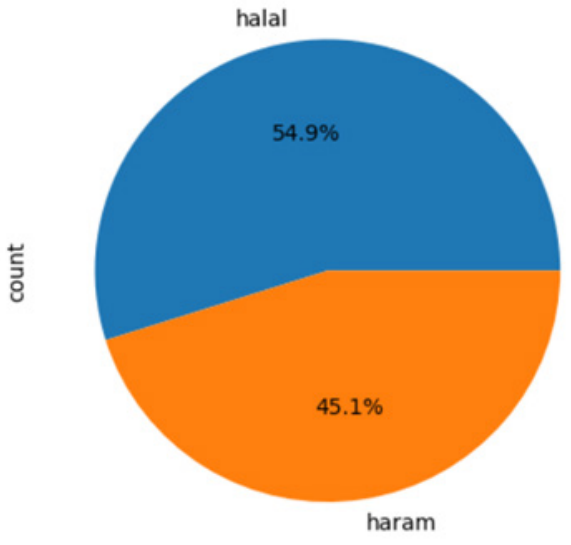


**Figure 1** Distribution of halal and non-compliant samples in the dataset

A detailed analysis of classification performance shows that the model performed consistently across both classes. The precision values reached 0.96 for halal-compliant products and 0.97 for non-compliant products, indicating a high degree of correctness in the model's predictions. Similarly, recall values of 0.98 for halal and 0.95 for non-compliant products confirm the model's strong ability to correctly identify relevant instances in both categories. The F1-score values, which balance precision and recall, further validate the robustness of the model, with scores exceeding 0.95 for both classes.

**Table 2** Performance metrics of the proposed Random Forest model

| Class | Precision | Recall | F1-score | Support |
|---|---|---|---|---|
| Halal | 0.96 | 0.98 | 0.97 | 6465 |
| Non-compliant | 0.97 | 0.95 | 0.96 | 5472 |
| Accuracy | - | - | 0.96 | 11937 |

Table 2 presents the performance metrics of the proposed classification model. The model achieved an overall accuracy of 96%, indicating a high level of reliability in distinguishing between halal and non-compliant products. High precision and recall values for both classes confirm the effectiveness of the model in identifying relevant patterns in ingredient data. These results suggest that the model is highly effective in capturing patterns within ingredient data and distinguishing between compliant and non-compliant products. The high recall for halal products indicates that the model successfully identifies the majority of compliant items, while the strong precision for non-compliant products highlights its ability to minimize false positive classifications. This balance is particularly important in the context of halal verification, where both misclassification of non-compliant products and unnecessary rejection of compliant products can have significant implications.

From a practical perspective, the applicability of the proposed model is especially relevant in the food ingredient and confectionery industry, where products often contain complex formulations. Examples include cake mixes, dessert creams, powdered bakery ingredients and fillings, which frequently incorporate additives such as emulsifiers, stabilizers and flavoring agents. These components can introduce ambiguity in determining halal compliance, particularly when their origin (plant-based or animal-based) is not explicitly specified.
The proposed AI-based approach enables automated analysis of such products by evaluating ingredient compositions and identifying potential risk components. This significantly reduces the need for time-consuming manual inspection and allows for rapid preliminary screening of large numbers of products. As a result, quality assurance processes can be optimized by focusing expert evaluation only on products classified as uncertain or high-risk.

Furthermore, the integration of the machine learning model within an IT-based framework enhances the overall functionality of the system. The proposed framework allows for structured data storage, efficient processing of ingredient information and real-time classification of products. This integration supports improved traceability, facilitates data-driven decision-making and increases transparency within halal certification processes.

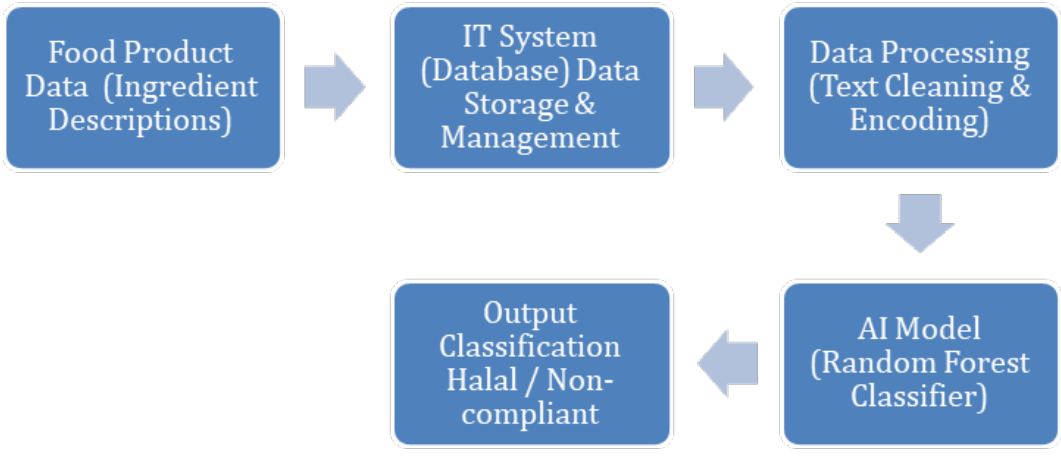


**Figure 2** Proposed AI-based system for halal compliance classification

Figure 2 presents the proposed system architecture integrating an IT-based data management layer with an AI-based classification model. The system processes ingredient data, transforms them into a structured format and applies a trained Random Forest model to classify products based on compliance criteria. Despite the strong performance of the model, certain limitations should be acknowledged. The classification results are dependent on the quality and representativeness of the dataset used for training. In cases where ingredient descriptions are incomplete or ambiguous, the model may produce uncertain or less reliable predictions. Additionally, the model does not inherently account for contextual factors such as the origin of specific additives, which may require further verification. Nevertheless, the findings of this study demonstrate that the application of machine learning techniques, combined with IT-based data management systems, provides a powerful and scalable approach for improving halal compliance verification. The proposed model represents a step towards the digital transformation of halal certification processes and highlights the potential for broader implementation in industrial and regulatory environments.

## Conclusions

The findings of this study confirm that the integration of Artificial Intelligence (AI) and Information Technology (IT) offers a robust and effective approach for improving halal compliance verification processes. The application of a Random Forest-based machine learning model to ingredient-level data resulted in high classification performance, achieving an overall accuracy of 96%, with consistently strong precision and recall across both halal-compliant and non-compliant categories. These results demonstrate the capability of data-driven models to capture relevant patterns in complex ingredient compositions and provide reliable classification outcomes. In addition to the quantitative performance, the study highlights the practical relevance of the proposed approach within contemporary food production systems. In sectors such as food ingredients and confectionery manufacturing, where product formulations often involve multiple additives and components with potentially ambiguous origins, the use of AI-based classification enables efficient preliminary screening. This significantly reduces reliance on manual inspection procedures and allows for faster identification of products that may require further expert verification. The integration of the machine learning model within an IT-based framework further enhances the applicability of the proposed solution. By combining structured data storage, automated preprocessing and real-time classification capabilities, the system supports improved traceability and facilitates data-driven decision-making. Such an approach

contributes to increased transparency and consistency in halal certification processes and aligns with ongoing trends in the digital transformation of food quality assurance systems. Nevertheless, certain limitations must be acknowledged. The performance of the model is inherently dependent on the quality, completeness and representativeness of the dataset used for training. In scenarios where ingredient descriptions are incomplete, inconsistent or lack sufficient detail, the reliability of the model's predictions may be reduced. Furthermore, the model does not explicitly incorporate contextual information such as the origin of specific additives, which remains a critical factor in determining halal compliance and may require additional verification mechanisms. Future research should focus on expanding the dataset to include a wider range of products and more detailed ingredient information, as well as exploring advanced machine learning and deep learning techniques for improved classification performance. Additionally, the development and validation of fully integrated systems within real industrial environments would provide valuable insights into the scalability and practical implementation of AI-driven halal verification frameworks. Overall, this study demonstrates that AI-based approaches, when combined with robust IT infrastructures, represent a scalable, efficient and reliable solution for enhancing halal compliance verification. The proposed model provides a foundation for further research and practical applications aimed at modernizing halal certification systems and improving transparency across the food industry.

## References

Bonne, K., Verbeke, W. (2008): Religious values informing halal meat production and the control and delivery of halal credence quality, *Agric. Hum. Values* 25 (1), 35-47.

Wilson, J.A.J., Liu, J. (2010): Shaping the halal into a brand?, *J. Islam. Mark.* 1 (2), 107-123.

Tian, F. (2017): A supply chain traceability system for food safety based on HACCP, blockchain and Internet of things, In: *Int. Conf. Service Systems and Service Management*, pp. 1-6.

Breiman, L. (2001): Random Forests, *Mach. Learn.* 45 (1), 5-32.

Iftekhar, A., Cui, X., Hassan, M., Afzal, W. (2021): Blockchain-based traceability system that ensures food safety measures to protect consumer safety and COVID-19 free supply chains, *Foods* 10 (6), 1289.

Casino, F., Kanakaris, V., Dasaklis, T.K., Moschuris, S., Stachtiaris, S., Pagoni, M., Rachaniotis, N.P. (2019): Modeling food supply chain traceability based on blockchain technology, *IFAC-PapersOnLine* 52 (13), 2728-2733.

Zhang, Y., Jin, R., Zhou, Z.H. (2010): Understanding bag-of-words model: a statistical framework, *Int. J. Mach. Learn. Cybern.* 1 (1-4), 43-52.

Jurafsky, D., Martin, J.H. (2009): Speech and Language Processing, New Jersey, USA: Pearson.

# UNAPREĐENJE SISTEMA HALAL USKLAĐENOSTI KROZ PRIMJENU UMJETNE INTELIGENCIJE I MAŠINSKOG UČENJA

**Aldijana Omerović[1], Azra Sinanović[1], Ragib Spahić[2],**

[1]Univerzitet FINRA Tuzla, Fakultet tehničkih nauka, Mitra Trifunovića Uče 9, 75000 Tuzla, Bosnia and Herzegovina
[2]Iffco Velvet doo, Hasana Merdžanovića 42, 71320 Vogošća, Bosnia and Herzegovina

*Corresponding author: Aldijana Omerović*
*E-mail address: aldijana.finra@gmail.com;*

*Pregledni rad*

## ABSTRACT

Sve veća potražnja za halal certificiranim proizvodima stvorila je potrebu za efikasnijim i pouzdanijim sistemima verifikacije. Tradicionalni procesi osiguravanja halal usklađenosti oslanjaju se na ručne inspekcije i laboratorijska ispitivanja, što može biti vremenski zahtjevno i podložno ljudskim greškama. Ovo istraživanje predlaže integrirani pristup zasnovan na umjetnoj inteligenciji (AI) i informacionim tehnologijama (IT) s ciljem unapređenja halal usklađenosti. Razvijen je model klasifikacije zasnovan na mašinskom učenju koristeći algoritam Random Forest, pri čemu su korišteni podaci o sastojcima iz označenog (labeled) skupa podataka. Model je obučen da klasificira proizvode u kategorije halal i neusklađenih proizvoda. Pored toga, predložen je IT okvir za podršku upravljanju podacima i osiguravanje sljedivosti. Eksperimentalni rezultati pokazali su da je model postigao tačnost od 96%, uz visoke vrijednosti preciznosti i odziva (recall). Ovi nalazi potvrđuju da sistemi zasnovani na umjetnoj inteligenciji mogu značajno unaprijediti efikasnost, tačnost i pouzdanost procesa halal verifikacije.

**Ključne riječi:** *halal usklađenost, umjetna inteligencija, mašinsko učenje, sljedivost, klasifikacija hrane.*

**JOURNAL
OF HALAL QUALITY AND CERTIFICATION**

# HALAL STATUS OF UNCONVENTIONAL ANIMAL SPECIES AS A SOURCE OF HUMAN NUTRITION

**Neira Fazlović[1], Faruk Čaklovica[1], Kenan Čaklovica[1]**

[1] Veterinary faculty, University of Sarajevo, Department of Food Safety and Environmental Protection, Zmaja od Bosne 90, 71000 Sarajevo, Bosnia and Herzegovina

*Corresponding author: Neira Fazlović*
*E-mail address: neira.fazlovic@vfs.unsa.ba*

*Review paper*

## ABSTRACT

The main purpose of Halal regulation is the obtainment of safe food for the Muslim and other populations. While the halal status of commonly grown animals, such as cattle and pigs, has been extensively studied, the debate regarding the unconventional animal species is still ongoing. In the modern world, where the importance of alternative sources of animal protein is on the rise, an exploration of halal status of different animals is necessary, especially in cases where all other demands, regarding general safety and means of sacrifice, have been met. For some species, the halal status has been determined already. Predatory birds and coprophagous animals are explicitly described as considered haram. Grazing beasts are considered lawful except those that are explicitly prohibited, which would mean species such as reindeer should be considered halal. Locusts are generally considered halal, which is of great importance, as insects are often seen as one of the most promising sources of animal protein for the future. While animals with fangs are declared as haram, marine hunting is allowed, which puts animals such as crocodiles in a controversial position, as some scholars consider them haram while others consider them halal. In addition, frogs are often considered haram, because the killing of frogs is prohibited. As this is a very demanding and complex issue, of an ethical, cultural, traditional, religious, gastronomic and health nature, our position on Halal status will be based on current scientific and theological knowledge about the animal species, its importance in the ecosystem and interaction with other animal species, threats and natural forms, which will determine our commitment to the potential use of the appropriate animal species in nutrition.

**Keywords:** *unconventional animal species, Halal status, human nutrition*

## Introduction

Islam is the fastest growing religion in the world with around two billion followers from all over the world, with many cultures and customs (Hackett et al, 2025). One of the most important parts of any culture is the food people consume, as it is deeply shaped by the customs, environment and other factors. However, when it comes to cultures with the Muslim majority population, a special focus has been put on the concept of halal food. For food to be considered halal, it needs to be allowed for the Muslim population to consume. These rules and guidelines have been extrapolated from the Quran as well as from Haddjid, in order to assure that Muslims consume only safe and healthy food. Some rules have to do with the way the food is prepared, while others are considered with the type of food (Rahman et al, 2024; Ahmad et al, 2025, Saidin and Yaakob, 2025). When it comes to meat, only meat of animals slaughtered by People of the Book can be consumed, if the animals were slaughtered in the name of Allah. Some animals have been explicitly proclaimed as halal, such as cattle (sheep, goats, camels, buffaloes), while others, such as pigs, have explicitly been described as haram. Carnivorous animals and birds of prey are also considered haram (Qureshi et al, 2012; Ahmad et al, 2023; Rahman et al, 2024, Azmi et al, 2024). Islam recognizes the concept of *Darura* (necessity), situations of extreme need, such as starvation or absence of any suitable sustenance where the consumption of haram food as a means of staying alive, given that the preservation of life supersedes dietary limitations (Azmi et al, 2024).

Due to climate changes, more and more attention is placed on the concept of sustainable farming, as conventionally farmed animals, such as cattle, require a lot of resources and thus have a greater effect on the environment (Gil et al, 2024, Burkart et al, 2026). In addition, consumers are looking for new and healthier sources of protein, in order to improve their nutrition and health. Given these factors, more attention is placed on unconventional animal species as a source of human nutrition. These species, such as insects, amphibians and snails are used for food production in some parts of the world. They are often farmed and bred, like more conventional animal species, but their use is usually limited to a certain area. Meat derived from these animals is often high in protein and necessary micronutrients, and is considered healthier than conventional meat species (Ologhobo et al, 2003; Cullere, 2014; Čaklovica et al, 2021). As the global market is more connected than ever, the availability of these animal species has increased, so consumers from all over the world have access to them and they are being farmed in places outside of those where they are traditionally kept, sometimes to great success (FAO, 2005; Domínguez et al, 2019).

With the rise of Islam all over the world and the general increase in human population, more questions are asked regarding the halal status of these unconventional animal species. In addition, in some countries, such as Indonesia, some of these unconventional animal species are considered a traditional delicacy (Qureshi et al, 2012; Grano, 2020). Therefore, it is necessary to consider if these species ought to be declared as halal and thus allowed for Muslim to consume. In this paper, we used sources from scholars all over the world in order to determine the halal status of different unconventional animal species, including frogs, snails, crocodiles, llamas, alpacas and reindeers, pigeons, ostriches and insects.

## Frogs

Frogs are amphibians that belong to the family *Anura* and account for around 88% of extant amphibian species. Given that they are one of the five most diverse vertebrate orders in the world, they can be found all over the planet, with the exception of very cold and very dry areas and they differ in size, habitat and diet among species. However, their shared characteristics are a lack of tail, as well as strong back legs that allow for a powerful jump (Encyclopaedia Britannica. (n.d.); Čaklovica et al, 2021).

As frogs are relatively small animals, only their hind legs are usually consumed. Frog legs can be prepared in numerous ways, from soups and screws to deep frying and are rich in many different compounds necessary for human health, such as omega-3 fatty acids, vitamin

A, and potassium. They have a mild flavor and are often said to taste like chicken, with a texture similar to that of chicken wings (Özogul et al, 2008, Čaklovica et al, 2021). They are consumed all over the world, from France, China, Indonesia, Italy as well as in Slavic countries such as Slovenia, Czech Republic and Ukraine. Frogs can be raised in industrial settings, but they are often caught wild, raising issues regarding sustainability of these wild populations (Grano, 2020; Auliya et al, 2023).
The halal status of frogs is in dispute in the Islamic circles. While frogs themselves are not explicitly forbidden to be consumed, the act of killing them is forbidden (Sunan Abu Dā'ūd: no. 3871). TheSafii, Hanafi, and Hanbali Islamic schools strictly forbid the consumption of frogs. Frogs are forbidden from being killed, and according to some scholars are thus prohibited from being eaten (Saidin and Yaakob, 2025). However, Maliki school permits certain types of frogs, such as the green frog, but species that have blistered skin are still considered haram, due to being seen as unclean and poisonous (Egypt's Dar al-Ifta. 2015; Clarke, 2020).

*Swikee* is a dish made of frog legs that is often consumed in Indonesia, the country with the largest Muslim population in the world, where it has sparked controversy. Given the haram status of frog consumption in mainstream Islam, it is considered forbidden in mainstream Islamic circles, but it is still consumed, as a part of tradition in this area (Grano, 2020; Haryono et al, 2023).

**Snails**

Snails are a large group of animals belonging to the group *Molluscs*. They are invertebrates with an open circulatory system, meaning the hemolymph is pumped by a heart into a body cavity called the hemocoel, where it directly bathes organs and tissues, bypassing a continuous network of vessels (Čaklovica et al, 2021, Baghele et al, 2022).

Snails have been consumed for a long time in different parts of the world. In Europe, especially in France, they are considered a delicacy in dishes known as *Escargot*, which is a French word for snail. They are consumed in many parts of Europe, Mediterranean and North Africa (Baghele et al 2022). They are considered a good source of protein, as they contain less fat and cholesterol compared to conventional meat. Generally, they are non toxic, relatively simple for gathering as well as farming (Čaklovica et al, 2021, Baghele et al, 2022).

The halal status of snails is one of the most controversial when it comes to unconventional animal species. Mostly, they are classified as haram, as they are considered as filthy animals (*khabaith*) (Sholeh, 2022). However, some scholars make a distinction between land and aquatic (marine) snails, as marine animals, with a few exceptions, are all considered halal (5:96 Quran). On the other hand, land snails (escargot) are permissible (halal) according to the Maliki school (nd, 2026), but considered forbidden (haram) or disliked by Hanafi, Shafi'i. and Hanbali schools

**Ruminants**

Cattle such as sheep, goats, camels and buffalos are considered as halal and are permissible to consume. However, in the recent decades, more types of ruminants have been domesticated and farmed for their meat. Among them are llamas (*Lama Glama*) and alpacas (*Vicugna pacos*) native to the South American continent. Closely related to camels, they are mostly grown for their wool, but their meat is also used in South American cuisine. Meat of these animals is considered healthy, as their carcasses have a low fat content (0.49%), as well as a low amount of cholesterol (51.1 mg/100 g) when compared to other sources of red meat (Polidori et al, 2007). Similarly, reindeers (*Rangifer tarandus*) have been grown and used as a source of food by the Sami people in the arctic for hundreds of years (Laruelle and Hohmann, 2020). Belonging to the family *Cervidae*, they are also ruminants. Their meat has a fat content of 2%, making it leaner than other sources of red meat (Hassan et al. 2012) Their meat is considered a good source of polyunsaturated fatty acids (linoleic, linolenic and arachidonic) and vitamin C, which leads to the reduction of arterial hypertension and atherosclerosis (Andronov et al, 2022).

The consumption of these animals should be

permitted, in cases where they are slaughtered by People of the Book and that other demands regarding general safety and way of slaughter had been met. Given that the consumption of these animals is still a novelty in many parts of the world, most animals don't meet the criteria and are not considered halal, but if these factors change, they ought to be allowed (Laruelle and Hohmann, 2020)

**Crocodiles**

While crocodiles are not domesticated, they are sometimes grown from wild caught eggs, mostly for their skins which are used in the fashion industry. However, in the recent decade, there has been an increase in the consumption of crocodile meat.

Their meat is considered delicate and tender, with low cohesiveness with high elasticity and tenderness. Lacking connective tissue, it is juicy, without the presence of an intense taste and an almost imperceptible aroma, often described as tasting like chicken and fish combined (Unajak et al, 2011; Fasulkova et al, 2024). As they are predators, crocodile meat carries certain risks that other types of meat considered halal does not, such as the presence of *Trichinella* spp, a zoonotic parasite found in the muscles of omnivores and carnivores (Fasulkova et al, 2024).

All species of crocodiles are considered predators, as they have fangs and are thus classified as haram (Saidin and Yaakob, 2025). Some scholars consider them as seafood, as they spend a significant part of their life in water, which would make them permissible for consumption. However, this opinion is the minority in the Islamic circles and crocodile meat is mostly classified as haram.

**Insects**

Many consumers are now paying attention to the sustainability of their food. The production of conventional sources of animal proteins, especially cattle, is often considered unsustainable, as it uses a lot of water, land and food (Članjak-Kudra et al, 2020, Rust et al, 2020). The benefits of insects as a food source is their fast growth rate, great rate of conversion of food to mass, and small requirements for food, water and space. These characteristics make insects a popular idea for the future of animal-based protein sources (Članjak-Kudra et al, 2020). They are consumed in many parts of the world already, which makes the need to determine their halal status even more important, with the rise of Muslim population.

When it comes to insects, locusts are considered halal, as they are mentioned in Hadith, consumed by the Prophet Muhammad. This type of insect has been consumed for centuries in the Arabian Peninsula and their status is very clear, even if they are not a popular choice among the Western consumers (Saidin and Yaakob, 2025).

The status of other insects is a matter of dispute between different schools of Islam. Some consider all insects to be halal, as long as they are not poisonous, while others see insect species other than locus as *khabeeth* (filthy) which would make them not permissible for consumption by Muslims. The consumption of impure and harmful things is strictly prohibited, but if the insects are not poisonous and have been farmed in a hygienic manner, some scholars consider them halal. Due to their similarity to locusts which are explicitly allowed, grasshoppers are often also considered halal, while the other species used for human nutrition, such as mealworms, are mostly prohibited (Tajudeen, 2020; Hamdan et al, 2025).

In the modern time, where the need for sustainable sources of protein is on the rise, the rules regarding edible insects need to be looked at closer (Riaz et al, 2025). However, this must never come at the cost of human safety. While our opinion is that grasshoppers should be considered halal, other species of insects require more information before they can be deemed safe.

**Ostrich**

Ostrich (*Struthio camelusis*, common ostrich) is the largest bird in the world, belonging to the phylum *Chordata* and order *Ratite*. Not capable of flight, they can weigh between 63.5 and 145 kilograms and are considered the fastest birds

on land, with the ability to run at 70 km/h. Despite their large size, they are herbivores and mostly eat plants, such as roots, grasses, fruit and leafy greens (Arain et al 2025). Due to their size and high productivity, they have been raised by humans for centuries, for their meat, their large eggs as well as their skin, which has been used in fashion. Ostriches are a highly adaptive species, as they naturally live in areas of extreme temperature and arid climates. Thus, they are a great species to be farmed in arid and semiarid areas of the world (Članjak-Kudra et al, 2023, Arain et al 2025).

The ostrich meat has been consumed for centuries, described as tasting as lean beef, but recent research indicates that this source of protein is healthy for human consumption. Compared to beef, it is lower in saturated fatty acid content, and low cholesterol level but high in polyunsaturated fatty acid contents (AL-KHALIFA et al, 2014, Članjak-Kudra et al, 2023). This type of meat contains bioactive compounds, including taurine, anserine, and glutathione, known for anti-inflammatory, antioxidant, and neuroprotective properties. Ostrich meat is also high in polyunsaturated fatty acids as well as omega-3 and omega-6 which are essential fatty acids. These components are known to reduce inflammation and support brain and heart function (Akram et al 2018).

Ostriches lack tallows like birds such as eagles and vultures and are herbivores, which means they meet the basic requirements regarding halal animals. Generally, they are considered halal, if they have been slaughtered in the proper way and if the other requirements regarding food safety have been met (Saidin and Yaakob, 2025). Given all these facts, ostrich meat is the red meat of choice for many who are seeking healthier lifestyles and they are raised all over the world. In addition, ostrich farming is a sustainable practice as it requires fewer natural resources like land, water, and feed than the traditional animal species (Akram et al, 2018, Arain et al 2025).

**Pigeon**

Pigeons and doves are birds belonging to the family Columbidae. The domestic pigeon (*Columba livia* "*domestica*") has been kept by humans since the time of the ancient Mesopotamia and ancient Egypt. They have been used as pets and as messengers, but also as food. Even if their use has diminished in the last century, they are still grown all over the world. They are herbivores, mostly sustaining on a diet of plants and grains (Islam et al, 2021, Čaklovica et al, 2021).

The meat of the pigeon is often referred to as squab. Some pigeons are raised for this purpose. The meat is described as tender and moist and is mostly said to have a richer and fuller taste than other commonly consumed meats, such as chicken. Squab is easily digestible meat, as it contains a lot of unsaturated fatty acids and very little connective tissue, with the meat coming from younger birds being softer and tastier (Hasan et al, 2016; Čaklovica et al, 2021, Zhang et al, 2025).

Unlike birds such as vultures, pigeons are herbivores who do not possess tallows, which would mean they ought to be considered halal, if other requirements, regarding food safety and the way of slaughter have been met. This is a nearly universal opinion among Islamic scholars and pigeon meat/squab is consumed in different Muslim countries (Saidin and Yaakob, 2025).

**Conclusion**

For certain unconventional animal species, their status as a potential source of human nutrition is very clear. Such is the case with unconventional species of ruminants, including reindeer, llama and alpaca, and birds like ostriches and pigeons, who should be considered as halal, as long as other requirements regarding the preparation of the meat and the slaughtering of animals have been met. In fact, some of these animals have been consumed by the muslim people for centuries, while others are just gaining popularity, leading to opportunities for the spread of halal certified industries.

On the other hand, species such as crocodiles ought to be considered haram and not used for human consumption. Their potential use in other fields, including leatherwork is a different

subject that is not a part of this research.

The biggest potential issue are the species where different schools of islam offer contradicting interpretations, such as frogs and snails. In case of insects, especially locusts and the similar species of grasshoppers that ought to be considered halal, the popularization of their consumption would be a net benefit for the planet, as they offer many benefits compared to conventional sources of animal protein. While they are relatively popular in places like Asia and the Middle East, the growing population of Muslims in the Western countries could benefit from consumption of this source of animal protein.

The main focus of rules regarding halal and haram food has always been ensuring the safety and wellbeing of consumers. In the ever-changing modern world, with more choice for the consumers than ever before, consumers need a guideline to help them choose food that is appropriate for them.

## Literature

(n.d.). Are Snails Halal?. Islam Question & Answer. https://islamqa.info/en/answers/114855/are-snails-halal

Abdullah James. "Are Frogs Halal?" The Halal Life, 1 July 2020.

Ahmad, A. M., Sipra, H. M., Tanveer, N., Aslam, N., Hassan, A., & Hassan, S. A. (2025). Ensuring halal food integrity: an overview of modern molecular and technological solutions. Food Biomacromolecules, 2(1), 5-22.

Ahmad, Nehaluddin, Lilly Suzana Binti Haji Shamsu, and Muhammad Danish Iqbal Ariffin. "Halal meat, food fraud, and consumer protection: A comparison of Islamic, European and Malaysian perspectives." J. Int'l L. Islamic L. 19 (2023): 80.

Akram, M. B., Khan, M. I., Khalid, S., Shoaib, M., & Azeema, S. (2019). Quality and sensory comparison of ostrich and goat meat. International Journal Life Science, 5(1), 2175-2183.

AL-KHALIFA, H.; AL-NASER, A. Ostrich meat: Production, quality parameters, and nutritional comparison to other types of meats. Journal of Applied Poultry Research, 2014, 23.4: 784-790.

Andronov, Sergei, et al. "The Relationships among Microelement Composition of Reindeer Meat (Rangifer tarandus) and Adaptation: A Systematic Review and Meta-Analysis." Sustainability 14.3 (2022): 1173.

Arain MA, Hassan FU, Ozdemir FA, Khaskheli GB, Malik Z, Buzdar JA, Fazlani SA. Ostrich Meat: A Review on Nutritional Properties and Health Benefits. Food Sci Anim Resour. 2025 Jul;45(4):965-980. doi: 10.5851/kosfa.2025.e30. Epub 2025 Jul 1. PMID: 41822834; PMCID: PMC12965222.

Asrorun Niam Sholeh, (2022, February 22). Land Snails, Halal Are They Consumed?. LPH LPPOM. https://halalmui.org/en/snail-land-halalkah-consumed/

Auliya, M., Altherr, S., Hughes, A., Nithart, C., Ohler, A., & Bickford, D. (2023). The European market remains the largest consumer of frogs' legs from wild species. Conservation, 3(1), 53-58.

Azmi. "What Can Muslims Not Eat? Guide to Islamic Dietary Laws." American Halal Foundation, 6 Sept. 2024, halalfoundation.org/what-can-muslim-not-eat/.

Baghele, M., Mishra, S., Meyer-Rochow, V. B., Jung, C., & Ghosh, S. (2022). A review of the nutritional potential of edible snails: A sustainable underutilized food resource

Burkart, S., Baca, M. F. D., Lerma, L. M., & Ángel, N. T. (2026). Impacts of sustainable cattle farming on the 2030 agenda: A global review. Agricultural Systems, 234, 104649.

Ĉaklovica, F., Đeđibegović, J., Marjanović, A., Ĉaklovica, K., Alagić, D., Ĉlanjak-Kudra, E., & Fazlović, N. NEKONVENCIONALNI IZVORI ANIMALNIH PROTEINA.

Članjak-Kudra, E., Fazlović, N., Alagić, D., & Čaklovica, K. (2022). Potential of insects as a source of animal proteins. MESO: Prvi hrvatski časopis o mesu, 24(3.), 271-280.

Članjak-Kudra, E., Fazlović, N., Mušanović, A., & Kapo, N. (2023). Uzgojne i etičke norme farmskog držanja nojeva s osvrtom na osobine nojevog mesa. MESO: Prvi hrvatski časopis o mesu, 25(6.), 516-525.

Cullere, M. (2014). Functional meat and meat products from unconventional meat species.

Domínguez, R., Pateiro, M., Munekata, P. E., Gagaoua, M., Barba, F. J., & Lorenzo, J. M. (2019). Exotic meats: An alternative food source. In More than beef, pork and chicken–The production,

processing, and quality traits of other sources of meat for human diet (pp. 385-408). Cham: Springer International Publishing.

Egypt's Dar al-Ifta. (2015, May 5). Is it permissible to catch, slaughter, and export frogs to lands where they are eaten?

https://www.dar-alifta.org/en/fatwa/details/9399/is-it-permissible-to-catch-slaughter-and-export-frogs-to-lands-where-they-are-e

Encyclopaedia Britannica. (n.d.). Frog. Retrieved from https://www.britannica.com/animal/frog

FAO - COMMITTEE ON AGRICULTURE. (n.d.).https://www.fao.org/4/j4196e/j4196e.htm?utm_

Fasulkova, R., Strateva, M., & Stratev, D. (2024). Carcass characteristics, nutritional value and safety of crocodile meat. Trakia Journal of Sciences, 22(3), 10-10.

Gil M, Rudy M, Duma-Kocan P, Stanisławczyk R, Krajewska A, Dziki D, Hassoon WH. Sustainability of Alternatives to Animal Protein Sources, a Comprehensive Review. Sustainability. 2024; 16(17):7701. https://doi.org/10.3390/su16177701

Grano, M. A. U. R. O. (2020). The Asian market of frogs as food for humans during COVID-19. Risk and consequences for public health. Medicine Papers, 6(4), 77-87.

Hackett, C. et al. (2025) Countries with the most Muslims & Global Muslim population change, 2010-2020, Pew Research Center. Available at: https://www.pewresearch.org/religion/2025/06/09/muslim-population-change/ (Accessed: 30 March 2026).

Hamdan, A., Hamdan, M. N., Chriki, S., Mokhtar, A. S., Mustafa, R. R., & Samat, A. B. (2025). Insect-based food as alternative protein source: an analysis from the islamic perspective. Journal of Insects as Food and Feed, 1(aop), 1-13.

Haryono, N. Y., Khusufi, R. L., Pangesti, D. W., Susanti, E., Mariana, R. R., Wardani, H. E., & Salim, N. (2023). Primer pairs specificity test for frog meat identification using pcr technique. Indonesian Journal of Chemistry, 23(5), 1315-1323.

Hasan, M. K., Mahbub, A. S. M., Hasnath, M. R., Beg, M. A. H., & Ahmed, T. (2016). Effects of age and live weight on meat yield characteristics of Giribaz squab (Doctoral dissertation, Faculty of Animal Science and Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh).

Hassan, AmmarAli, TorkjelM Sandanger, and Magritt Brustad. "Level of selected nutrients in meat, liver, tallow and bone marrow from semi-domesticated reindeer (Rangifer t. tarandus L.)." International Journal of Circumpolar Health 71.1 (2012): 17997.

Islam, O., Khatun, S., Famous, M., & Uddin, M. N. (2021). Comparative studies on squab growth performance and egg morphometrical attributes of different pigeon breeds. Animal Husbandry, Dairy and Veterinary Science, 5, 1-5.

Laruelle, M., & Hohmann, S. (2020). Polar Islam: Muslim Communities in Russia's Arctic Cities. Problems of Post-Communism, 67(4-5), 327-337.

Ologhobo, A., Mosenthin, R., & Adeyemo, G. (2003). Unconventional livestock: classification and potential uses. Nigerian Journal of Animal Science, 6(1), 111-121.

Özogul, F., Özogul, Y., Olgunoglu, A. I., & Boga, E. K. (2008). Comparison of fatty acid, mineral and proximate composition of body and legs of edible frog (Rana esculenta). International Journal of Food Sciences and Nutrition, 59(7-8), 558-565.

Polidori, P., Antonini, M., Torres, D., Beghelli, D., & Renieri, C. (2007). Tenderness evaluation and mineral levels of llama (Lama glama) and alpaca (Lama pacos) meat. Meat Science, 77(4), 599-601.

Qureshi, S. S., Jamal, M., Qureshi, M., Rauf, M., Syed, B. H., Zulfiqar, M., & Chand, N. (2012). A review of halal food with special reference to meat and its trade potential. Journal of Animal and Plant Sciences, 22(Supplement No 2), 79-83.

Rahman, M. M., Razimi, M. S. A., Ariffin, A. S., & Hashim, N. (2024). Navigating moral landscape: Islamic ethical choices and sustainability in Halal meat production and consumption. Discover Sustainability, 5(1), 225.

Riaz, Mian Nadeem, Fariha Irshad, and Awis Qurni Sazil. "Halal perspectives on grasshoppers (Locusts): A path to sustainable and nutritionally acceptable alternative protein source." Comprehensive Reviews in Food Science and Food Safety 24.5 (2025): e70283.

Rust NA, Ridding L, Ward C, Clark B, Kehoe L, Dora M, Whittingham MJ, McGowan P, Chaudhary A, Reynolds CJ, Trivedy C, West N. How to transition to reduced-meat diets that benefit people and the planet. Sci Total Environ. 2020 May 20;718:137208. doi: 10.1016/j.scitotenv.2020.137208. Epub 2020 Feb 8. PMID: 32088475; PMCID: PMC7184671.

Saidin, N., & Yaakob, M. A. Z. (2025). Permissible and Prohibited Animals in Islam: Insights from the Qur'an and Hadis. Journal of Halal Science and Management Research, 1(1), 189-204.

Sunan Abu Da'ud, Chapter Regarding the Disliked Remedies, Kitāb al-Tibb, no. 3871, pp. 1507.

Surah Al-Ma'idah Ayat 96 (5:96 Quran)

TAJUDEEN, Ahmad Labeeb. Halal certification of insect-based food: a critique. International Journal of Islamic Business Ethics, 2020, 5.2: 100-112.

Unajak, S., Meesawat, P., Anyamaneeratch, K., Srikulnath, K., & Choowongkomon, K. (2011). Identification of species (meat and blood samples) using nested-PCR analysis of mitochondrial DNA. African Journal of Biotechnology, 10(29), 5670

Zhang, Yan, Seong-ho Choi, and Shuang Liang. "Factors affecting the growth performance of domestic squab." Poultry Science (2025): 105945.

# HALAL STATUS NEKONVENCIONALNIH ŽIVOTINJSKIH VRSTA KAO IZVORA LJUDSKE ISHRANE

**Neira Fazlović[1], Faruk Čaklovica[1], Kenan Čaklovica[1]**

[1]Veterinarski fakultet, Univerzitet u Sarajevu, Odsjek za sigurnost hrane i zaštitu okoliša, Zmaja od Bosne 90, 71000 Sarajevo, Bosna i Hercegovina

*Autor za korespodenciju: Neira Fazlović*
*E-mail address: neira.fazlovic@vfs.unsa.ba*

*Pregledni rad*

## SAŽETAK

Glavna svrha halal regulative je osiguravanje sigurne hrane za muslimansku, ali i za ostalu populaciju. Iako je halal status uobičajenih domaćih životinja, poput goveda i svinja, detaljno istražen, rasprava o nekonvencionalnim životinjskim vrstama još uvijek traje. U savremenom svijetu, gdje raste važnost alternativnih izvora životinjskih proteina, neophodno je istražiti halal status različitih životinja, posebno u slučajevima kada su ispunjeni svi drugi zahtjevi koji se odnose na opću sigurnost i način klanja. Za neke vrste halal status je već jasno određen. Ptice grabljivice i koprofagne životinje izričito se smatraju haram. Pašinske životinje smatraju se dozvoljenim, osim onih koje su eksplicitno zabranjene, što znači da bi vrste poput soba (irvasa) mogle biti halal. Skakavci se generalno smatraju halal, što je posebno važno jer se insekti smatraju jednim od najperspektivnijih izvora životinjskih proteina u budućnosti. Iako se životinje sa očnjacima smatraju haram, morski lov je dozvoljen, što dovodi do kontroverzi oko životinja poput krokodila, jer ih neki učenjaci smatraju haram, dok ih drugi smatraju halal. Pored toga, žabe se često smatraju haram, jer je njihovo ubijanje zabranjeno. Kako je ovo vrlo složeno i zahtjevno pitanje etičke, kulturne, tradicionalne, religijske, gastronomske i zdravstvene prirode, stav o halal statusu zasniva se na savremenom naučnom i teološkom znanju o životinjskim vrstama, njihovoj ulozi u ekosistemu i međusobnim interakcijama, prijetnjama i prirodnim oblicima, što određuje pristup mogućem korištenju odgovarajućih životinjskih vrsta u ishrani.

**Ključne riječi:** *nekonvencionalne životinjske vrste, halal status, ljudska ishrana*

**AGENCIJA ZA CERTIFICIRANJE HALAL KVALITETE BiH**

Agency for Halal Quality Certification

Turalibegova 73, 75000 Tuzla
Bosna i Hercegovina
Tel. +387 35 258 427 • Fax +387 35 258 427
e-mail: agencija@halal.ba
**www.halal.ba**