



Halal Alternative Sources of Gelatin: A Review

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Received : November 2, 2023

Revised : November 22, 2023

Accepted : November 23, 2023

Online : November 26, 2023

Abstract

This article explores the growing interest in halal alternative sources of gelatin, driven by the need to provide suitable options for individuals adhering to Islamic laws. The overall methodology of this review involves a systematic examination using search engines from online databases, encompassing journals published from 2006 to 2023. The rationale for seeking alternatives beyond porcine gelatin is examined, considering religious and ethical considerations. Promising halal alternative sources are discussed, including animal-based gelatin, plant-based alternatives gelatin, aquatic animal-derived gelatin, microbial and fungal sources, as well as synthetic and recombinant gelatin. Each alternative is evaluated for its potential to meet halal requirements and applicability in various industries. The article also delves into the obstacles faced by the industry in adopting alternative gelatin sources, focusing on technological challenges and consumer acceptance. Technological challenges encompass replicating the functional properties of traditional gelatin, ensuring stability and shelf life, and addressing compatibility issues in diverse applications. Consumer acceptance and awareness pose challenges related to taste and texture perception, cultural and dietary preferences, and effective labelling and communication. Despite these challenges, the shift towards halal alternative sources of gelatin presents an opportunity for innovation in the food and pharmaceutical industries. It requires collaborative efforts between researchers, industry professionals, and regulatory bodies to overcome obstacles, ensure compliance with halal standards, and provide diverse consumer options following Islamic principles.

Keywords *Gelatin, Halal Alternative Gelatins, Gelatin Applications, Halal Products, Halal Industry*

INTRODUCTION

The halal industry has witnessed significant growth in recent years as consumers worldwide seek products that align with their religious and ethical beliefs (Fikadu et al., 2023). According to approximations, 70% of global Muslims consume halal products (Marohom & Fuerzas, 2023). Central to the halal dietary requirements is avoiding certain ingredients, such as gelatin derived from non-halal sources (Wulandari et al., 2016). Gelatin is a protein derived from collagen, a natural protein present in animals' connective tissues, skin, and bones. It is commonly obtained from the collagen of pigs and cows (Abedinia et al., 2020). Making gelatin involves boiling the collagen-containing parts of animals, followed by a filtration and drying process. The resulting substance is a flavourless, colourless, and odourless powder that could form a gel when mixed with a liquid (Alipal et al., 2021).

Gelatin is widely used in the food industry as a gelling agent in various products such as desserts, candies, marshmallows, and jellies (Zarubin et al., 2021). It is also used in the pharmaceutical and cosmetic industries for encapsulation and as a thickening or stabilizing agent (Lin et al., 2017; Liu et al., 2015). However, due to its animal-derived nature, gelatin is not suitable

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for some individuals following vegetarian, vegan, or certain religious dietary restrictions, such as those observed by Muslim consumers who adhere to halal guidelines (Nirwandari, 2020). The growing interest in alternative gelatins, including plant-based, marine-based, and certain animal-based options, has been reported in numerous studies. However, not all alternative gelatins are considered halal. Some alternative gelatins may be derived from non-halal sources. In addition, there are still many alternative gelatins reported recently. Thus, this paper primarily explores recent discoveries of halal alternative gelatins derived from various sources, such as terrestrial and aquatic animals, microbes, fungi, synthetic and recombinant sources. Additionally, the study reviews and discusses the applications of halal alternative gelatins beyond food products.

LITERATURE REVIEW

The global Muslim population has exceeded 1.8 billion (Rahmawati et al., 2023), making Islam the second-largest religion globally, following Christianity (Ayob & Saiyed, 2020). Halal products have expanded beyond food to encompass cosmetics, pharmaceuticals, fashion, and more (Sudarsono & Nugrohowati, 2020). This diversification has significantly contributed to the overall growth of the Halal market. There is a growing awareness among Muslim consumers regarding halal products, with particular attention to raw materials such as gelatin, which raises considerations of its halal or haram source (Usman et al., 2021). The market size for gelatin is projected to reach 5.0 billion USD by 2025, driven by the current demand for gelatin. The majority of gelatin is obtained from pig skin (46%), bovine hides (29.4%), pig and cattle bones (23.1%), and fish skin (1.5%) (Rather et al., 2022).

Gelatin is an animal-derived hydrocolloid (Karim & Bhat, 2008). Hydrocolloids are substances that form gels or viscous dispersions when they encounter water. They are often used in the food industry as thickening, gelling, stabilizing, or emulsifying agents. Hydrocolloids can be derived from various sources, including plants, seaweed, microbes, and animals (Alipal et al., 2021; Pancar et al., 2016).

Gelatin has a wide range of applications in the food, pharmaceutical, and other industries due to its unique properties, such as its ability to form gels, provide texture, and act as a stabilizing agent (Abdelmalek et al., 2016; Alipal et al., 2021; Rosli et al., 2023; Yeo et al., 2014). Some common applications of gelatin include:

1. Food Industry (Karim & Bhat, 2008; Ramli et al., 2023; Sultana et al., 2018)
 - a. Desserts: Gelatin is frequently used to make desserts such as gelatin salads, fruit-flavoured gelatin desserts, and puddings.
 - b. Confectionery: It is a key ingredient in producing gummy candies, marshmallows, and other chewy sweets.
 - c. Dairy Products: Gelatin is used in dairy products like yoghurt and cream cheese to improve texture and consistency.
 - d. Jams and Jellies: Gelatin is used as a gelling agent in producing jams, jellies, and fruit preserves.
2. Pharmaceuticals (Ahmady & Abu Samah, 2021; Al-Nimry et al., 2021)

Gelatin is used to make capsules for oral medications. Gelatin capsules are easily digestible and dissolve rapidly in the stomach, releasing the medication. It is also used to produce soft gel capsules for liquid or oil-based medications and dietary supplements.
3. Photography (Calixto et al., 2018; Liu et al., 2021)

Gelatin is used in the production of photographic film and paper. Gelatin emulsions help capture and stabilize the light-sensitive silver halide crystals in photographic materials.
4. Cosmetics (Al-Nimry et al., 2021)

Gelatin is used in some cosmetic products, including face masks and anti-ageing creams, for

its skin-smoothing and thickening properties.

5. Packaging (Luo et al., 2022; Ramos et al., 2016; Rather et al., 2022; Soo & Sarbon, 2018)

a. Edible Coatings:

Gelatin can be used to create edible coatings for fruits and vegetables. These coatings serve as a protective barrier, helping to extend the shelf life of fresh produce by reducing moisture loss and inhibiting microbial growth. Edible coatings can enhance the appearance and freshness of the produce.

b. Edible Films:

Gelatin can be processed into thin, flexible films that are edible. These edible films can be used to encapsulate or wrap individual food items, providing a protective layer. This is especially useful for products like candies, where the edible film can act as a barrier against moisture, oxygen, and contaminants.

c. Encapsulation of Flavors and Nutrients:

Gelatin is often used to encapsulate flavours, colours, and nutrients. This involves entrapping these sensitive compounds within a gelatin matrix to protect them from degradation due to exposure to air, light, or other environmental factors. This technique is commonly employed in producing flavour capsules for beverages and food products.

d. Gelatin-Based Adhesives:

Gelatin can be used as a natural adhesive for food packaging. It is employed in producing glue-like substances applied to seal packages, such as confectionery or pharmaceutical products.

e. Biodegradable Packaging:

Gelatin-based materials can contribute to the development of biodegradable packaging options. These materials can replace traditional plastics in some applications, offering an environmentally friendly alternative. Gelatin films may be used for single-use items, reducing the environmental impact associated with conventional packaging.

f. Edible Straws and Cutlery:

Gelatin can be used to produce edible straws and cutlery. These items can be consumed along with the food, eliminating the need for disposable plastic alternatives. They provide a sustainable and eco-friendly option for reducing plastic waste.

g. Confectionery Packaging:

Gelatin is commonly used in the production of capsules for pharmaceuticals and vitamins, which are often packaged in blister packs. Gelatin capsules can protect sensitive substances and allow for precise dosing.

h. Meat and Poultry Packaging:

Gelatin-based films or coatings may be applied to meat and poultry products to improve their appearance, extend shelf life, and reduce the risk of contamination. Gelatin coatings can provide a protective barrier against oxygen and other external factors.

6. Biomedical Applications (Piao et al., 2021; Rana et al., 2022; Xiang & Cui, 2021)

Gelatin is used in various biomedical applications, including drug delivery systems, wound dressings, and tissue engineering. Its biocompatibility and ability to form gels, such as hydrogels, make it useful in these contexts.

7. Art Conservation (Mosleh et al., 2023)

Gelatin is used in the conservation of art and historical artefacts. It can be employed as an adhesive or consolidant in restoring and preserving paintings and other items.

Gelatin is derived from animal products, specifically from the collagen found in animals' skin, bones, and connective tissues. The specific animal sources can vary, but commonly used

sources include porcine and bovine skin and bone (Yeo et al., 2014; Zarai et al., 2012). It is also worth noting that, for various reasons including religious dietary restrictions, cultural practices, and personal preferences, the consumption of gelatin derived from certain animals may be prohibited in some communities. For example, pig gelatin would not be considered halal in Islamic dietary practices, and there are also dietary restrictions in certain Hindu and vegetarian traditions (Abedinia et al., 2020).

Additionally, some people may choose not to consume gelatin derived from certain animals due to ethical or environmental concerns also Jews and Muslims such as insect melon bug (*Coridius viduatus*) and sorghum bug (*Agonoscelis versicoloratus versicoloratus*) (Mariod & Fadul, 2015) or frog (Tümerkan et al., 2019; Karnjanapratum & Benjakul, 2020). As a result, there is an increasing demand for alternative gelatin derived from non-animal sources in the food industry to accommodate various dietary preferences and restrictions (Zamzahaila et al., 2021).

RESEARCH METHOD

The review methodology for investigating halal alternative sources of gelatin involves a systematic approach. This process includes key elements such as utilizing top-tier search engines from leading online databases, formulating specific search terms related to the topic, and meticulously selecting the highest quality research articles for both literature review and comparative analysis. The review team searched four major online databases—Google Scholar, ScienceDirect, Scopus, and PubMed—to gather relevant articles focused on gelatin applications and alternative sources. The period of publication was selected from 2006 to 2023. The literature review adheres to the PRISMA guidelines (Liberati et al., 2009).

Literature Review

The authors conduct an extensive literature review to gather existing knowledge and insights into the current state of the halal industry, with a focus on gelatin alternatives. Explore academic journals, industry publications, and reports to understand the historical context, challenges, and advancements in the search for halal gelatin substitutes. Identify key trends, emerging technologies, and consumer preferences shaping the landscape.

Comparative Analysis

The authors perform a comparative analysis of traditional and alternative gelatin sources mentioned in the articles. Evaluate factors such as gelling properties, nutritional content, sensory attributes, and applications in the food and pharmaceutical industries. Assess the strengths and weaknesses of each alternative to provide a comprehensive understanding of their viability in halal product development.

FINDINGS AND DISCUSSION

Based on previous research works that have been conducted by many researchers for halal alternative sources of gelatin. This article will discuss three main points: the rationale for seeking alternatives beyond porcine gelatin, promising halal alternative sources, and obstacles in adopting alternative gelatin in the industry.

The Rationale for Seeking Alternatives Beyond Porcine Gelatin

Religious and Cultural Considerations

Porcine gelatin is derived from pigs, and its use may conflict with dietary laws and restrictions in certain religions, such as Judaism and Islam, where the consumption of pork is prohibited. Seeking alternative sources aligns with the need to respect and adhere to religious

dietary guidelines (Zamzahaila et al., 2021).

Vegetarian and Vegan Preferences

The rise in vegetarian and vegan lifestyles has led to an increased demand for plant-based alternatives to animal-derived products. Porcine gelatin, being an animal product, is not suitable for those following plant-based diets. Seeking alternatives addresses this growing consumer trend (Ramli et al., 2023).

Ethical and Environmental Concerns

Concerns about animal welfare and the environmental impact of traditional animal farming practices have fueled a shift toward more sustainable and ethical sourcing. Alternative sources that are not reliant on animal products contribute to more ethical and environmentally friendly practices (McClements & Grossmann, 2021).

Promising Halal Alternative Sources

Animal-Based Gelatin

Gelatin derived from halal sources, such as cows, chickens, and poultry slaughtered in accordance with Islamic laws, is considered permissible (halal) for consumption in accordance with Islamic principles. In halal slaughtering, specific guidelines and rituals are followed to ensure that the animals are slaughtered in a humane and permissible manner (Rather et al., 2022).

Plant-Based Gelatin Alternatives

Plant-based gelatin alternatives offer several advantages, including being considered halal (permissible) and contributing to environmental sustainability by potentially reducing carbon footprints. Plant-based gelatin alternatives, sourced from seaweed, fruits, and other plant materials, are generally considered halal. This makes them suitable for individuals following Islamic laws, providing a permissible alternative to animal-derived gelatin. Plant-based alternatives contribute to environmental sustainability by potentially reducing carbon footprints and addressing broader ecological concerns. The production of plant-based gelatin alternatives often involves more efficient resource use, reduced greenhouse gas emissions, and a lower environmental impact compared to traditional animal-derived gelatin (McClements & Grossmann, 2021; Ramli et al., 2023).

Aquatic Animal-Derived Gelatin

A key advantage of aquatic animal gelatin, including fresh water and marine sources, is that it is permissible (halal) in Islamic laws. Unlike certain land animals considered haram (forbidden), marine sources such as fish are generally accepted in Islamic practices. Additionally, marine gelatin is not subject to the specific slaughtering requirements (halal slaughtering) that are necessary for land animals according to Islamic law (Lin et al., 2017; Rosli et al., 2023).

Furthermore, marine gelatin sources, being distinct from bovine sources, are not associated with the risk of diseases affecting cows, such as bovine spongiform encephalopathy (BSE), commonly known as mad cow disease (Eryilmaz et al., 2017; Jaswir et al., 2016). This adds an extra layer of safety and acceptability for individuals adhering to Islamic guidelines (Lin et al., 2017).

Microbial and Fungal Sources

Advances in biotechnology have led to the development of microbial and fungal-based gelatin substitutes. Microorganisms like bacteria and yeast can be engineered to produce gelatin-like proteins through fermentation processes. These alternatives provide a halal-certified option without compromising the functional properties of gelatin, ensuring compatibility with various

applications in the food and pharmaceutical industries (Berninger et al., 2021; Sultana et al., 2018).
Synthetic and Recombinant Gelatins

Synthetic and recombinant gelatins represent innovative approaches to gelatin production, offering alternatives to traditional animal-derived sources. These alternatives are engineered through biotechnological processes and are designed to address ethical, religious, and cultural considerations while providing functional properties similar to traditional gelatin (Fushimi et al., 2020).

Table 1. Sources of Gelatin Replacement

Alternative Sources	Hydrocolloids	Extracted Sources	Properties	Applications	References
Animal-based gelatin	Gelatin	Cow	Gelling agent, thickening agent, and stabilizer	Jellies, candies, bakery products, pharmaceutical products	(Wulandari et al., 2016)
		Goat	Gelling agent	Food additives	(Mad-Ali et al., 2017)
		Poultry (Chicken, duck)	Fat replacement, film formation, foaming and emulsifying	Food products, edible film, food packaging,	(Abedinia et al., 2020; Soo & Sarbon, 2018; Suderman & Sarbon, 2020; Yeo et al., 2014; Yuliani et al., 2019)
Plant-based gelatin	Agar-Agar	Red algae or seaweed	Gelling agent, film	Chewing gum, desserts, pastry/bakery, jellies), beverages (clarification and refining), confectionery, edible film	(Roy et al., 2023; Sousa et al., 2021)
	Carrageenan	Red Seaweed	Gelling agent, film, thickening agent	Food additive, encapsulation, edible films/coatings, plant-based analogues,	(Udo et al., 2023)

Alternative Sources	Hydrocolloids	Extracted Sources	Properties	Applications	References
				and 3D/4D printing	
	Starch	Sago palm	Film formation	Biodegradable film and pharmaceutical applications	(Zhu, 2019)
	Guar Gum	Guar beans	Thickening and stabilizer	Salad dressing, bakery products, frozen dairy dessert	(Ramli et al., 2023)
	Pectin	Cell walls of fruits (orange, mango, banana, watermelon, guava, and Mangosteen peels)	Gelling agent	Jams, jellies, Fruit spreads and milk dairy products	(Jaswir et al., 2016)
		Okra	Gelling agent	Jams, jellies	(Rahman et al., 2017)
	Locust Bean Gum	Seeds of the carob tree	Thickening and gelling agent	Yoghurt	(Pancar et al., 2016)
	Konjac Gum	Root of the konjac plant	Thickening and gelling agent	Bakery products	(Ramli et al., 2023)
Aquatic animal-based gelatin		Alaska Pollock	Gelling agent	Food additives	(Zhou et al., 2006)
	Gelatin	Sea cucumber (<i>Stichopus japonicus</i>)	Antioxidant activity	Functional foods, cosmetics and pharmaceuticals or nutraceuticals	(Wang et al., 2010)

Alternative Sources	Hydrocolloids	Extracted Sources	Properties	Applications	References
		Cobia (<i>Rachycentron canadum</i>)	Gelling agent	Food additives	(Silva et al., 2014)
		Squid (<i>Loligo vulgaris</i>)	Visco-elastic, gelling agent	Food additives	(Abdelmalik et al., 2016)
		Cuttlefish	Antioxidant agent	Food additive	(Jridi et al., 2014)
		Jellyfish	foaming and emulsifying agent.	food and medical applications	(Charoencho kpanich et al., 2022)
		Nile tilapia	Stabilizer, thickening agent	yoghurt	(Hirbo et al., 2023)
		Atlantic salmon (<i>Salmo salar</i>)	gelling properties, film formation	Food additive, edible film	(Arnesen & Gildberg, 2007; Fan et al., 2017)
		Yellowfin tuna (<i>Thunnus albacares</i>)	gelling properties	Food additive	(Mafazah et al., 2018)
		Marine snail (<i>Hexaplex trunculus</i>)	gelling agent	Food additive	(Zarai et al., 2012)
		Golden carp (<i>Probarbus jullieni</i>)	gelling agent	Food additive	(Ali et al., 2018)
	Collagen	Echinoderms	fibrillar collagen to produce membranes	Regenerative medicine	(Coppola et al., 2020)
		Sea Cucumber	fibrous protein and insoluble	Nutraceutical pharmaceutical applications	(Desmelati et al., 2020)
Microbial	Xanthan gum	Bacteria (<i>Xanthomon</i>)	Gelling agent, thickening	Frozen dairy dessert, Jelly formulation	(In et al., 2023; Ramli et

Alternative Sources	Hydrocolloids	Extracted Sources	Properties	Applications	References
		<i>as campestris)</i>	agent, and stabilizer	for food 3D printing	al., 2023; Sworn, 2021)
Synthetic and recombinant Gelatins	Synthetic collagen	Polypeptide	Flexibility materials	Autografts and allografts, biomaterials	(Fushimi et al., 2020)
	Gelatin-mimetic protein	Komagataell a- pfaffi (<i>Pichia pastoris</i>)	Adhesion, non-toxicity and biocompatibility	Biomedical Applications	(Gellerman n et al., 2019)

Obstacles to Adopting Alternative Gelatin in the Industry

Technological Challenges

Achieving similar functional properties to traditional gelatin, such as texture, mouthfeel, and stability, can be challenging with alternative sources. Researchers and industries face the obstacle of matching the performance of traditional gelatin in various applications. Ensuring comparable gelling strength, texture, and stability is crucial for widely accepting alternative gelatins in various applications. However, attaining equivalent stability and extended shelf life, as observed with traditional gelatin, may pose challenges when utilizing certain alternative sources.

Consumer Acceptance and Awareness

Consumers often have ingrained taste and texture expectations linked to traditional gelatin, which can influence their preferences. Consumer dietary choices and cultural factors play a substantial role in determining acceptance levels. Furthermore, there is a limited awareness among consumers regarding alternative gelatins. In certain regions, products incorporating alternative gelatins may not be readily available. Challenges may arise regarding cost-effectiveness and the accessibility of alternative sources compared to traditional gelatin. Economic factors and market demand are pivotal in determining the industry's adoption of alternative gelatin.

CONCLUSIONS

In conclusion, this study highlighted a dynamic and diverse terrain in the ongoing exploration of halal alternative sources for gelatin. Researchers and industry stakeholders are actively engaged in finding solutions to the limitations associated with traditional gelatin, motivated by ethical considerations, adherence to religious principles, and consumers' evolving preferences. The comprehensive review has elaborated on the progress made in diverse alternatives, including plant-based extracts, microbial and fungal derivatives, insect-derived gelatin, as well as synthetic and recombinant gelatins. The literature review also emphasizes the need for continued research and collaborative efforts to address challenges associated with technological adaptations, regulatory complexities, and consumer acceptance. The reviewed literature collectively points towards a future where halal gelatin alternatives can not only meet the stringent requirements of Islamic dietary practices but also contribute to sustainability and cater to a broader range of dietary preferences.

LIMITATION & FURTHER RESEARCH

The limitations of exploring halal alternative sources of gelatin may include the restricted availability and accessibility of certain substitutes. For instance, certain plant-based or marine-derived gelatins might be less common or more expensive than conventional animal-derived gelatin. Additionally, the functional properties of these alternatives may differ, potentially impacting the final product in terms of texture, taste, or stability. Another limitation could be the lack of standardized regulations for halal certification across different regions, leading to inconsistencies in classifying gelatin sources as halal. This makes it challenging for consumers and manufacturers to confidently navigate the market.

As for further research, conducting comparative analyses between various halal gelatin alternatives and traditional gelatin is essential. This involves evaluating their sensory, textural, and nutritional attributes in various applications. Such analyses can guide manufacturers in selecting the most suitable alternatives for specific products. Additionally, conducting consumer studies to understand the perception and acceptance of products using halal gelatin alternatives is crucial. This research provides insights into market trends and helps in tailoring products to meet consumer preferences.

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