



Potential of gelatin as functional ingredient in food products: A review

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Abstract

Gelatin is a natural biopolymer produced through the hydrolysis of collagen present in animal tissues such as skin, bones, and connective materials. It exhibits distinct physicochemical and functional characteristics that make it highly valuable in food formulation and processing. This review examines the extraction techniques, structural properties, and functional applications of gelatin obtained from various animal sources. Variations in raw materials and extraction parameters significantly influence gelatin yield, gel strength, and viscosity, thereby affecting its overall quality and performance. Gelatin functions as a gelling, stabilizing, foaming, and film-forming agent, and is also utilized in edible coatings that prevent oxidation and microbial spoilage. Its biodegradability, biocompatibility, and recognized safety as a food additive strengthen its potential for sustainable and innovative food production. Consequently, gelatin represents a versatile functional ingredient that plays an essential role in enhancing the texture, stability, and nutritional attributes of food products.

Article History

Received September 1, 2025

Accepted November 12, 2025

Published November 19, 2025

Keywords

Biopolymer, Functional Properties, Gelatin

1. Introduction

Food manufacturers have frequently encountered problems related to product stability and textural quality. Many food products tend to exhibit insufficient stability and lack the desired soft and elastic texture. To achieve a chewy and smooth consistency, the addition of gelling agents such as gelatin is required (1). Gelatin plays a vital role in food product development because it functions as a thickener, stabilizer, gelling agent, and protective barrier that prevents contamination while enhancing nutritional quality. Protein-rich materials containing collagen serve as the primary raw sources in the production of gelatin (2).

Gelatin is classified as a hydrocolloid capable of transitioning reversibly between sol and gel states (3). It can be extracted from animal tissues, including bones, cartilage, skin, and connective layers. Common animal sources include fish, cattle, poultry, and pigs, which contain substantial amounts of gelatin (4). Nevertheless, gelatin derived from particular animals may not be suitable for all consumers due to religious dietary restrictions (5). Gelatin is very flexible in its utilization in the food industry.

In the food industry, gelatin serves multiple functions such as an emulsifier, stabilizer, foaming agent, encapsulating material, and film-forming substance. Its functional versatility also enables it to act as a dietary additive, salt reducer, flocculating agent, protein enhancer, and adhesive (6). Utilization of gelatin in several food products such as jelly candy, marshmallow, pudding, panacotta, ice cream, and gelato (7). Food products resulting from

the utilization of gelatin will have better quality in terms of organoleptic, shelf life, and nutritional value.

The properties and functionality of gelatin are strongly influenced by its raw material sources and extraction method (7). These factors affect its physical, chemical, and mechanical behavior, determining its suitability for various food applications. Modifying processing parameters or incorporating other biopolymers such as polysaccharides and proteins can enhance its stability, texture, and film-forming ability (8). on the utilization of gelatin from cobia, catfish, and payus fish bones to improve the characteristics of marshmallows. This review provides updated insights into the potential of animal-derived gelatin as a multifunctional ingredient and highlights its role in improving food quality, preservation, and innovation.

2. Materials and Methods

The search for articles (original or review) was performed using the Google Scholar and Scopus electronic databases until July 2025. The main keywords used were: “animal based gelatin,”; “gelatin utilization for food,”; “gelatin extraction,”; “characteristic of animal based gelatin,” and “functional roles of gelatin,” among others. All the included references were manually selected and reviewed by the authors.

3. Results and Discussion

3.1. Bioactive Overview of Gelatin as a Functional Biopolymer

Gelatin is a biopolymer protein produced through the hydrolysis process of collagen derived from animal-based sources (9). Gelatin consists of 18 different amino acids, reflecting its nature as a compound derived from protein (10). It can be extracted from various animal tissues such as bones, skin, cartilage, and connective structures (4). Gelatin is typically characterized as a translucent, colorless, and flavorless material that becomes brittle when dried. It is edible and possesses multiple functional attributes, including its roles as a dietary ingredient, salt-reducing agent, flocculating substance, protein enrichment component, and adhesive (6). The arrangement of amino acids within the gelatin polymer, as illustrated in Figure 1, reflects its origin from collagen and underpins its diverse functional attributes.

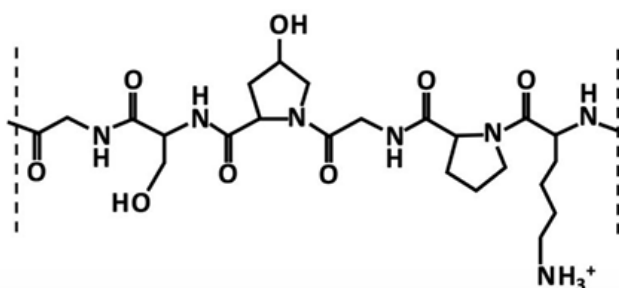


Figure 1. The chemical structure of gelatin (11).

Gelatin can act as an antioxidant and antibacterial so that it can be utilized in several food products (12). In the food industry, gelatin can be used as a gelling agent, emulsifier, stabilizer, foaming agent, encapsulant, and film-former (8). Gelatin can be applied to several food products such as jelly candy, marshmallow, pudding, panacotta, ice cream, and gelato. (7). The incorporation of gelatin into food formulations enhances the overall quality,

sensory attributes, and nutritional value of the resulting products. This biopolymer exhibits high solubility in water and achieves homogeneity at temperatures of approximately 71°C (13). Moreover, gelatin is classified as a food-safe additive since it does not contain artificial colorants, flavoring agents, preservatives, or synthetic chemicals (8).

3.2. Extraction and Production Process of Gelatin

The procedure for the production of gelatin can be carried out using fish skin as the primary raw material. Initially, the skin is pretreated and cut into small pieces to increase the surface area for subsequent reactions (Figure 2). The samples are then soaked in a 0.01 M NaOH solution containing 1% hydrogen peroxide (H_2O_2) at 4 °C for 24 hours to remove non-collagenous proteins and impurities. Following this, defatting is performed using 10% isopropanol at 4 °C for 4 hours to eliminate residual fats. The material is then swelled in 0.05 M acetic acid at 4 °C for 4 hours to disrupt the collagen structure and facilitate gelatin extraction. The extraction process is conducted with distilled water at 45 °C for 10 hours to solubilize the gelatin. The obtained extract is then centrifuged at 18,000×g for 20 minutes at 10 °C to separate the gelatin-containing supernatant. Finally, the supernatant is freeze-dried to obtain gelatin powder in its stable and usable form (14).

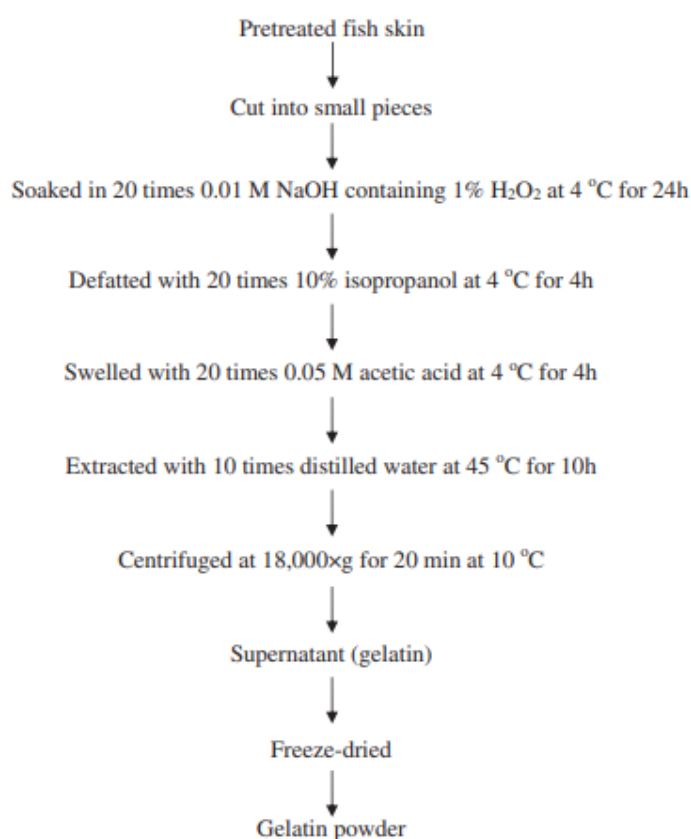


Figure 2. Flowchart of gelatin isolation process (14).

3.3. Sources and Raw Materials of Gelatin

Sources of gelatin can be obtained from bones, skin, connective tissue in animals such as fish, cattle, chicken, and pigs (15). The source of gelatin is very important to consider, for example animals exposed to diseases such as Bovine Spingofom Encephalopathy (BSE) and

swine influenza which are important factors in food and drug safety, gelatin sourced from certain animal proteins can cause allergies for consumers (4). Therefore, it is very important to know the source of gelatin that will be utilized in making products. Gelatin sourced from food ingredients that are rich in nutrients will produce food products with high nutritional value (4). The characteristics of the gelatin produced will vary based on the source. The color of gelatin sourced from fish has a crystalline white color while gelatin sourced from cattle has a pale white color as well as the pH of gelatin sourced from fish is 5.25, the pH of gelatin sourced from cattle is 5.68, and the pH of gelatin sourced from pigs is 7.5 (8). Each animal has different collagen content so the gelatin content is different.

3.4. Comparison of Gelatin Yield, Gel Strength, and Viscosity from Previous Animal Sources

Several studies have reported variations in gelatin yield, gel strength, and viscosity obtained from different animal-based sources. Each type of raw material contributes distinct physicochemical characteristics that influence the quality and functionality of the resulting gelatin.

Table 1. Gelatin yield, gel strength, and viscosity values from different animal-derived materials, showing variations influenced by the type of raw source.

Source	Gelatin Yield	Gel Strength	Viscosity	Reference
Tongkol fish	12.2%	71.481 bloom	3.44 cP	(16)
Patin Fish	6.14%	364.19 bloom	3.83 cP	(17)
Goat skin	8.12%	-	-	(18)
Cow leather	10.52%	74.85 bloom	2.55 cP	(19)
Pig skin	12.87%	74.41 bloom	8.37 cP	(20)
Boiler chicken thighs and legs	3.85-9.52%	264.3 bloom	-	(21)
Buffalo leather	25-30.2%	196 bloom	23.02 cP	(22)
Red snapper fish	4.93%	312.5 bloom	17.4 cP	(23)
White snapper fish	18.03%	251.11 bloom	5.8 cP	(9)
Belida fish	8.8%	151.45 bloom	3.45 cP	(24)
Payus fish	10.89%	191.79 bloom	3.62 cP	(25)
Stingray	11.04-16.8%	312.5 bloom	-	(26)
Tuna fish	16.95%	59.43 bloom	6.5 cP	(27)
Mujair fish	9.439%	-	5.24 cP	(28)
Katombo fish	6.442%	-	2.93 cP	(29)
Tilapia fish	12.98%	132.54 bloom	2.59	(30)
Milkfish	9.78%	-	16.25 cP	(31)
Carp fish	4.33%	-	5 cP	(32)
Catfish	11.4%	82.1 bloom	-	(33)
Cobia fish	17.88%	392.24 bloom	5.63	(8)

Based on the data presented in Table 1, it is evident that each animal source exhibits distinct characteristics in terms of gelatin yield, gel strength, and viscosity. The highest gelatin yield was observed in buffalo skin, ranging from 25% to 30.2%, while cobia fish

demonstrated the greatest gel strength at 392.24 bloom, and red snapper showed the highest viscosity value at 17.4 cP. A high gelatin yield reflects a greater degree of collagen hydrolysis from animal tissues (34). Increased gel strength values indicate an improved ability to form stable gels. Variations in gel strength among samples are influenced by differences in habitat and collagen composition, both of which affect the final gel quality [8]. Conversely, lower gel strength may result from excessive hydrolysis during extraction, which shortens amino acid chains and reduces molecular interactions with water, thereby hindering gel formation (26). In addition, higher viscosity values indicate superior thickening properties. The viscosity of gelatin is affected by the collagen structure, as longer amino acid chains contribute to greater viscosity variations among sources (8).

3.5. Industrial Applications and Functional Roles of Gelatin

Gelatin has broad applications in the food industry and can be employed as a gelling agent in products such as marshmallows and jelly candies, providing them with a desirable chewy texture (35). Due to its hygroscopic nature, gelatin is capable of binding water molecules, which enhances its effectiveness as a gelling agent in various food systems. During the gel formation process, gelatin also facilitates the binding of fiber, as it interacts with and protects soluble fiber components such as pectin and gum (36). Furthermore, gelatin serves as an emulsion stabilizer in ice cream and other dessert formulations, contributing to improved texture and stability (37). It is also used in the development of edible films owing to its glycine, proline, and hydroxyproline content, which imparts flexibility and ease of application to food surfaces (38). The use of gelatin-based edible coatings helps protect food surfaces from direct oxygen exposure, minimizing oxidation and microbial contamination that can accelerate spoilage (39). In addition, gelatin exhibits antibacterial properties that inhibit the growth of pathogenic and spoilage microorganisms, thereby extending product shelf life (40). Beyond these functions, gelatin demonstrates several valuable properties, including polymerization capability, biodegradability, antioxidant activity, and antibacterial potential (41). The biodegradability, biocompatibility, non-toxicity, water solubility, and strong emulsifying ability also make gelatin an effective encapsulating agent for bioactive compounds (42). Gelatin can additionally act as a foaming agent due to its capacity to stabilize foam structures, resulting in longer-lasting foams (8). It functions as a co-emulsifier, supporting emulsion stability by preventing the aggregation of dispersed globules and maintaining uniform distribution within the emulsion system (9). Moreover, gelatin can serve as a nutritional enhancer in food products, as gelatin derived from nutrient-rich animal sources high in protein and fat contributes to products with improved nutritional composition (4). The protein present in gelatin can also interact with other food proteins, enhancing product elasticity and overall texture quality (36).

4. Conclusions

Gelatin functions as a versatile biopolymer obtained from collagen-rich animal tissues such as skin, bones, and connective materials. The physicochemical and functional characteristics of gelatin, including yield, gel strength, and viscosity, are strongly influenced by the source of raw materials and the extraction conditions applied. Its multifunctionality allows gelatin to serve as a gelling, stabilizing, emulsifying, foaming, and film-forming agent, contributing significantly to the development of food products with improved texture, stability, and nutritional quality. Furthermore, the biocompatibility, biodegradability, and

safety of gelatin as a food additive enhance its potential for broader industrial applications. Advancements in extraction technology and the utilization of alternative sources, particularly aquatic species, present promising opportunities for sustainable gelatin production. Overall, gelatin represents a valuable functional ingredient that plays a crucial role in enhancing the quality, safety, and innovation of modern food products.

Acknowledgments

Not applicable.

Author Contributions

Conceptualization, C.E.U.; methodology, C.E.U.; validation, C.E.U.; formal analysis, C.E.U.; resources, C.E.U.; data curation, C.E.U.; and writing C.E.U.

Funding

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Data Availability Statement

Available data are presented in the manuscript.

Conflicts of Interest

The author declares no conflict of interest.

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