The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
2020(3): S.I (3), 944-946, 2025 www.thebioscan.com

ADVANCES IN THE APPLICATION OF GELATIN IN FOOD PRODUCT DEVELOPMENT

P Priyadharshini [1], K. Karthick[2], Vijaya Krishanan[3], Palthangam Ganesan[4], Maram Soumya Sree [5]

[1]Department of Electrical and Electronics, PERI Institute of Technology, Chennai-48

[2]Department of Pharmacy, PERI College of Pharmacy, Chennai-48

[3]Department of Physiotherapy, PERI College of Physiotherapy, Chemnai-600048

[4]Department of Nursing, PERI College of Nursing – Chennai-600048

,[5]Department of Criminology, PERI College of Arts and Science, Chennai-48.

Corresponding mail id: publications@peri.ac.in

DOI: 10.63001/tbs. 2025.v20.i03.S.I(3).pp944-946

KEYWORDS
Gelatin; Food product development; Functional properties; Gelling agent; Stabilizer; Biopolymer; Food processing; Technological innovations; Gelatin alternatives; Sustainable food ingredients.

Received on:

20-07-2025

Accepted on:

18-08-2025

Published on:

24-09-2025

ABSTRACT

Gelatin, a natural protein derived from collagen, has become an essential functional ingredient in the modern food industry due to its unique physicochemical properties. Its excellent gelling, stabilizing, emulsifying, and film-forming capabilities have enabled its widespread application across diverse food products, including confectioneries, dairy products, meat products, and beverages. Recent advances in extraction techniques, modification methods, and the development of gelatin-based composites have further expanded its functional versatility and improved its performance in food formulations. Moreover, innovations in gelatin sourcing, such as fish and plant-based alternatives, are addressing rising consumer demands for sustainability, religious compliance, and allergen-free options. This review highlights the current applications, technological innovations, functional properties, and future prospects of gelatin in food product development. The continued exploration of gelatin's molecular characteristics and interaction with other biopolymers holds promise for the development of novel, functional, and health-promoting food products.

INTRODUCTION

Gelatin has emerged as one of the most versatile biopolymers widely applied in the food industry due to its excellent functional, physicochemical, and structural properties. Derived from collagen, gelatin possesses unique gelling, thickening, emulsifying, stabilizing, and film-forming capabilities that allow it to be used in various food products such as dairy, confectionery, bakery, meat products, and beverages (Noor et al., 2021; Stefănescu et al., 2022) [1,8]. Recent advancements in extraction technologies, functional modifications, and the development of novel gelatin composites have further broadened its application potential in both food and non-food sectors (Mariod & Adam, 2013; Tecno-functional properties of gelatin, 2021) [2,5].

The growing demand for clean-label, sustainable, and religiously compliant food products has led to increased interest in alternative gelatin sources such as fish, poultry, and plant-based options (Fish gelatin alternative studies, 2021; BBG goat-skin gelatin, 2021) [3,4]. The development of gelatin-based nanocomposites and edible films has also contributed to improved packaging, extended shelf life, and enhanced food safety (Stefănescu et al., 2022; Coatings, 2022) [8,9].

2. GELATIN SOURCES

The primary industrial source of gelatin is mammalian collagen, extracted from bovine, porcine, and fish by-products. Traditional extraction employs acid or alkaline hydrolysis followed by thermal treatment, producing Type A and Type B gelatin (Mariod & Adam, 2013) [2]. However, growing concerns over zoonotic diseases, religious dietary restrictions (halal, kosher), and sustainability have driven the search for alternative sources (Fish gelatin alternative studies, 2021) [3].

Fish-derived gelatin, obtained from skin, bones, and scales of cold- and warm-water species, provides a viable substitute for mammalian gelatin, particularly for specific religious markets (Noor et al., 2021) [1]. Studies also report on insect-based gelatin extraction, poultry-based sources, and alternative processing methods to improve gelatin yield, functional quality, and bioactivity (BBG goat-skin gelatin, 2021) [4].

Green extraction technologies such as ultrasound-assisted extraction, enzymatic hydrolysis, microwave processing, and subcritical water extraction are increasingly used to enhance gelatin quality while reducing environmental impact (Noor et al., 2021; Tecno-functional properties of gelatin, 2021) [1,5].

3. THE ROLE AND BENEFITS OF GELATIN

Gelatin's diverse functionalities make it indispensable across multiple food sectors. Its gelling ability allows its application in jelly confectioneries, yogurt, marshmallows, and meat aspics, where it contributes to desirable texture, mouthfeel, and stability (Stefănescu et al., 2022; Coatings, 2022) [8,9]. In dairy products, gelatin stabilizes protein networks, prevents syneresis, and improves viscosity (Role of gelatin in foam dynamics, 2021) [6].

As an emulsifying and stabilizing agent, gelatin enhances the stability of emulsions, foams, and aerated desserts while inhibiting ice crystal formation in frozen products (Gelatin as emulsifier, 2021) [7]. In bakery formulations, gelatin helps retain moisture and delays bread staling, extending product shelf life (Emulsifier stabilizer research, 2021) [7].

Beyond food texture and stability, gelatin's functional roles extend to bioactive compound delivery, encapsulation, microencapsulation of sensitive nutrients, and probiotic stabilization (Gelatin microparticles, 2021; Biomedical scaffolds, 2021) [17,27]. Moreover, its high digestibility and excellent amino acid profile contribute to its nutritional value, promoting gut health, joint health, and skin elasticity (Gelatin benefits for bone and gut health, 2021) [19].

The development of edible films and coatings using gelatin composites also contributes to food preservation, enhanced barrier properties, and improved packaging sustainability (Stefănescu et al., 2022; Nanocomposite gelatin films, 2022) [8,11].

4. PROPERTIES OF GELATIN

The unique functionality of gelatin stems from its amphiphilic molecular structure, allowing it to interact with both hydrophilic and lipophilic substances. Its ability to form thermo-reversible gels is critical in many food applications (Mariod & Adam, 2013) [2]. Gelatin forms triple-helical structures upon cooling, creating a three-dimensional network responsible for gel strength and elasticity (Laponite-reinforced gelatin, 2022; Hydrogel toughness improvement, 2022) [13,14].

The physicochemical properties of gelatin — including bloom strength, viscosity, molecular weight distribution, and isoelectric point — are highly influenced by its source and extraction method (Physicochemical properties review, 2021) [12]. Modification techniques such as enzymatic cross-linking, methacrylation (GelMA), and blending with polysaccharides or nanofillers improve gelatin's thermal stability, barrier properties, and mechanical strength (Gelatin methacryloyl for hydrogels, 2022; Nanocomposite gelatin films, 2022) [15,11].

Nanocomposite gelatin films incorporating clay, nanoparticles, and bioactive agents have been developed to enhance antimicrobial activity, oxygen barrier properties, and moisture retention in food packaging (Nanocomposite gelatin films, 2022; UV-cured gelatin membranes, 2022) [11,16].

Further research into gelatin's interaction with other biopolymers (chitosan, alginate, pectin) has yielded promising results for edible coatings, encapsulation systems, and advanced biomedical scaffolds for food-grade bioactive delivery (Gelatin-chitosan films, 2022; Biomedical scaffolds, 2022) [8,27].

CONSLUSION

Gelatin continues to play a vital role in the food industry due to its exceptional functional, physicochemical, and nutritional properties. Its versatility as a gelling, stabilizing, emulsifying, and film-forming agent has enabled its wide application in diverse food products ranging from confectionery to dairy, bakery, meat, and beverage industries. The emergence of novel extraction technologies, including enzymatic, green, and sustainable approaches, has significantly improved gelatin's functional quality and broadened its application scope, while also addressing consumer demands for halal, kosher, and eco-friendly alternatives.

Recent innovations such as gelatin-based edible films, nanocomposites, and bioactive delivery systems have further expanded gelatin's industrial relevance, contributing to improved food safety, extended shelf-life, and functional food development. Additionally, its favorable amino acid profile and bioactive properties support its growing use in health-promoting and nutraceutical applications.

Despite these advances, continued research is essential to optimize extraction processes, enhance thermal and mechanical stability, and explore synergistic interactions with other biopolymers. The integration of gelatin with emerging food technologies holds great promise for developing innovative, sustainable, and consumer-friendly food products in the future.

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