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REVIEW ARTICLE

Development and technological perspectives of low-sugar gelled fruit creams

Desarrollo y perspectivas tecnológicas de cremas de frutas gelificadas con bajo contenido de azúcar

Zulema Llorente-Romero[1] • **Edwin F. Cerda**[2]

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Abstract This review examines the application of hydrocolloids, particularly natural gums like xanthan gum and locust bean gum (LBG), in the production of low-sugar fruit gel products, including creams, jellies, and marmalades. Their technological applications, blending efficiency, and functional properties are explored, along with a comparison with traditional pectin. The studies analyzed demonstrate that these gums can enhance the texture, stability, and rheological properties of reduced-sugar formulations, while also providing acceptable sensory characteristics and promoting the production of healthier foods. Advances in product development, such as gel creams, are also being identified, along with research focused on specific formulations. However, technical and economic limitations are recognized, such as variability in gum quality and cost, which can hinder their industrial implementation. Finally, the focus is on trends in clean labeling, the potential for innovation in the functional food industry, and the growing consumer preference for natural and sustainable products, consolidating alternative hydrocolloids as a tool for the future of food development.

Keywords hydrocolloids, gelled creams, low sugar content, natural gums, food development.

Resumen La presente revisión aborda el uso de hidrocoloides, especialmente gomas naturales como la goma xantana y la goma de algarrobo (LBG), en el desarrollo de productos gelificados de frutas con bajo contenido de azúcar, como cremas, jaleas y mermeladas. Se exploran sus aplicaciones tecnológicas, eficiencia en mezclas, propiedades funcionales y su comparación con la pectina tradicional. Los estudios analizados evidencian que estas gomas pueden mejorar la textura, la estabilidad y las propiedades reológicas de las formulaciones reducidas en azúcar, además de aportar características sensoriales aceptables y favorecer la elaboración de alimentos más saludables. También se identifican avances en el desarrollo de productos como cremas gelificadas, así como investigaciones centradas en formulaciones específicas. No obstante, se reconocen limitaciones técnicas y económicas, como la variabilidad en la calidad de las gomas y su costo, que pueden dificultar su implementación industrial. Finalmente, se destacan las tendencias en etiquetado limpio, potencial de innovación en la industria de alimentos funcionales y la creciente preferencia del consumidor por productos naturales y sostenibles, consolidando a los hidrocoloides alternativos como una herramienta para el futuro del desarrollo alimentario.

Palabras clave hidrocoloides, cremas gelificadas, bajo contenido de azúcar, gomas naturales, desarrollo de alimentos.

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Zulema Llorente-Romero
zulema.llorente@uniremington.edu.co

Corporación Universitaria Remington, Medellín, Colombia.

[1]Corporación Universitaria Remington, Medellín, Colombia.
[2]Facultad de Ciencias Agropecuarias y Recursos Naturales, Universidad Técnica de Cotopaxi, Latacunga, Ecuador.

PUBLIS EDITORIAL

Introduction

In recent decades, a global trend toward consuming healthier foods has emerged, particularly those with low sugar content and high nutritional value. This preference responds, in part, to the recommendations of international organizations such as the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO), which promote increased fruit and vegetable intake as a strategy to prevent chronic non-communicable diseases, including obesity, type 2 diabetes, and cardiovascular disease (FAO, 2019; WHO, 2020).

Guava (*Psidium guava* L.), a tropical fruit of the Myrtaceae family, has been recognized for its high content of vitamin C, dietary fiber, phenolic compounds, and carotenoids, which give it significant nutraceutical value (García & Manriquez-Hernández, 2016; Jiménez-Escrig et al., 2021). Its versatility allows it to be consumed both fresh and processed into products such as nectars, jams, jellies, and creams. Gelled fruit creams, particularly guava cream, represent a popular option in the food industry due to their semi-solid texture, concentrated flavor, and ease of consumption (Ma et al., 2022).

Traditionally, these products are made with high concentrations of sugar and pectin, which contribute to both their preservation and their gel structure (Chávez-Salazar et al., 2021). However, growing consumer interest in low-sugar foods has prompted research into technological alternatives that maintain the desired organoleptic and rheological properties without compromising product quality (Xiong et al., 2024).

Xanthan gum and locust bean gum have gained prominence due to their ability to form stable gel structures, mainly when used in synergistic combinations. These mixtures can mimic the functionality of pectin in low-saccharide matrices, while providing technological benefits such as improved viscosity, texture, and stability of the system (Gao et al., 2024).

The development of low-sugar gelled creams and the use of mixed hydrocolloid systems pose a challenge from a formulation perspective, but also an opportunity for innovation in the design of functional and dietary foods. Therefore, this paper aims to review advances in the development of guava gelled creams using xanthan and carob gums as alternative gelling agents, evaluating their technological potential in low-sugar formulations.

Gelled creams: definition, traditional formulation, and characteristics

Gelled creams are semi-solid products obtained from a combination of fruit purees or pulps, gelling agents, sugars, and, in some cases, other functional ingredients or preservatives. Their main characteristic is their smooth and firm texture, resulting from the action of gelling agents that structure the food matrix. These products aim to provide a sensorially appealing and technologically stable alternative within the processed food sector (Wang et al., 2022).

Traditionally, the formulation of gelled creams includes a fruit or fruit mix as a base, such as guava, mango, or strawberry, added sugars (sucrose, glucose syrup), pectin as a gelling agent, citric acid to adjust the pH, and preservatives, including potassium sorbate. Pectin is one of the most widely used hydrocolloids due to its ability to form gels under acidic conditions and in the presence of sugars (Chaturvedi et al., 2021). However, with the growing demand for healthy foods, there has been increasing interest in reducing sugar content and using alternative gelling agents, such as xanthan gum, locust bean gum, or agar (Azeredo et al., 2020).

From a physicochemical perspective, gelled creams must maintain a uniform texture without syneresis (liquid release), have a controlled pH, and exhibit stability during storage. Furthermore, their sensory value depends on the synergy between flavor, color, aroma, and consistency, which is essential for consumer acceptance (Mounika et al., 2021). Several factors, including the concentration of soluble solids, the type and concentration of the gelling agent, and the processing technique employed, determine gel quality.

In technological terms, the production of gelled creams involves steps such as homogenization, controlled heating, sequential addition of ingredients, and hot filling, followed by sealing and cooling. These processes maintain product safety, minimize microbial growth, and ensure a long shelf life (Hernández-Carranza et al., 2021).

Currently, there is a trend toward developing functional gelled creams that incorporate bioactive compounds, probiotics, or natural sweeteners such as stevia or erythritol, in response to consumer concerns about metabolic health and calorie content (Tovar et al., 2023). These innovations require careful reformulations that maintain the desired texture without compromising product stability.

Quality parameters

Traditional political campaigns have been transformed by thQuality parameters in gelled products, such as fruit creams, are essential to ensure consumer acceptability, storage stability, and compliance with technical standards. These parameters can be grouped into physicochemical, microbiological, sensory, and rheological parameters (Table 1). Among the most evaluated physicochemical parameters are pH, total soluble solids (°Brix), titratable acidity, moisture content, and water activity, as they directly influence the stability and safety of the product (Basu et al., 2017). For example, adequate pH control prevents the growth of pathogenic microorganisms, while soluble solids are indicators of the sugar content and the degree of ripeness of the processed fruit.

Table 1. Technological and functional parameters for the characterization of low-sugar gelled fruit creams

Parameter	Description
Soluble solids (°Brix)	Affects texture, firmness, and microbiological stability
pH and titratable acidity	Determines gelation and controls food safety
Water activity	Influences physical and microbiological stability
Humidity	Related to texture, shelf -life, and syneresis
Texture (TPA and rheology)	Includes hardness, cohesiveness, elasticity, adhesiveness, G′, G″
Color and vitamin C	Indicators of degradation due to heat or oxidation
Sensory evaluation	Inclusion of hedonic and descriptive attributes of the gel
Proximal composition	Macro/micronutrient balance, especially in low-sugar formulations

In the case of gelled creams, rheological properties such as viscosity and firmness are also monitored, which depend on the type of gelling agent used. These parameters determine the texture and sensory experience, key aspects in the product's acceptance by the end consumer. Microbiological analyses, including aerobic mesophilic, coliform, and fungal/yeast counts, ensure that the product meets food safety requirements throughout its shelf life (Charoenphun et al., 2025). Compliance with these standards is crucial, particularly for low-sugar formulations, which are more susceptible to microbiological deterioration. Regarding sensory parameters, acceptance, preference, and sensory profile tests allow for the evaluation of characteristics such as color, aroma, flavor, texture, and overall acceptability. These studies are key to the product's commercial success (Salgado et al., 2022). Gelled products must exhibit stability during storage, as evaluated by the variation of the parameters above over defined periods under controlled conditions of temperature and humidity (Ben Rejeb et al., 2020).

Role of sugar and pectin in conventional formulation

In traditional gelled cream formulations, sugar and pectin act synergistically to develop the product's characteristic semi-solid texture, stability, and sensory acceptability.

Sugar, usually in the form of sucrose, plays several roles, reducing water activity, inhibiting microbial growth and contributing to product preservation; it favors the gelation of high methoxyl pectin (HM, DE > 50%), since it concentrates the aqueous phase, promotes hydrophobic interactions and allows the formation of hydrogen bonds between pectin chains in an acidic environment (pH 2.8-3.5) and high solids content (> 55-75%) (Xu, 2023).

It also directly influences texture, determining properties such as firmness, viscosity, and cohesiveness. Various studies show that the higher the sugar concentration, the greater the consistency of the gel, to the point where it can crystallize and weaken it (Hassan et al., 2018).

Pectin, on the other hand, is a polysaccharide present in cell walls and is the gelling agent par excellence. It is classified into high methoxyl (HM) and low methoxyl (LM, DE < 50%). HM requires high sugar and low pH to gel through hydrogen bonding and hydrophobic forces, while LM gels in the presence of calcium, with less sugar, and over a wider pH range (3–6) (Lara-Espinoza et al., 2018; Gawkowska et al., 2018).

The molecular structure—including molecular weight, degree of esterification, and branching of RG-I and RG-II—determines the ability to form a stable three-dimensional network (Lara-Espinoza et al., 2018).

The synergy between both components is essential. In traditional gels with HM pectin, sugar acts as a dehydrating agent, limiting the hydration of pectin molecules and promoting their association (Lara-Espinoza et al., 2018). In LM pectins, although sugar is not essential for gelation, moderate concentrations (10-20%) improve firmness and reduce syneresis, whereas excess sugar can interfere with calcium cross-linking (Gawkowska et al., 2018).

The appropriate combination of acid, sugar, and type of pectin generates "junction" zones where the inter- and intramolecular bonds essential for a firm and stable reticular network are formed (Gawkowska et al., 2018; Xu, 2023).

This formulation balance results in products with a firm, cohesive texture, high elastic modulus (G′) versus G″ values, indicative of a solid-elastic gel; high sensory stability, without syneresis or visual degradation, when the sugar content and pectin type are adequately controlled; and extended shelf life, thanks to the low water activity and unfavorable pH for microorganisms, without compromising organoleptic properties.

Limitations of excessive sugar use

Excessive sugar consumption has been widely linked to multiple public health problems, both metabolic and psychological, which has prompted the search for alternatives to reduce its consumption in processed foods.

First, excess sugar intake is closely linked to an increased prevalence of metabolic diseases such as obesity, type 2 diabetes, and cardiovascular disease. High consumption of free sugars contributes to insulin resistance, dyslipidemia, and body fat accumulation, especially when consumed in the form of sugary drinks or ultra-processed foods (Johnson et al., 2009; Malik et al., 2019). Furthermore, high sugar intake triggers chronic inflammatory processes that contribute to the development of chronic non-communicable diseases (Ma et al., 2022).

From a psychological perspective, recent studies indicate that a diet high in sugar can negatively influence mental health. For example, excessive sugar intake has been associated with an increased risk of depression and anxiety, likely mediated by alterations in the gut microbiota and systemic inflammation (Xiong et al., 2024).

In the oral health sector, high sugar consumption is a determining factor in the etiology of dental caries. The fermentation of sugars by oral bacteria produces acids that demineralize tooth enamel, thereby increasing the incidence of caries, particularly in children and adolescents (Moynihan & Kelly, 2013).

Furthermore, from a nutritional perspective, excessive sugar consumption can lead to the displacement of essential nutrients in the diet, a phenomenon known as “nutrient displacement”. This occurs when calories from sugar replace foods rich in vitamins, minerals, and fiber, reducing overall nutritional quality and increasing the risk of deficiencies (Hart et al., 2025).

High sugar use can also limit the formulation of healthy foods, as its reduction poses technological challenges related to the texture, flavor, and stability of the product, motivating the search for alternative ingredients and reformulation strategies (Mahato et al., 2024).

Reformulation of low-sugar creamers

The reformulation of low-sugar spreads is a key strategy for responding to the growing demand for healthier food products, particularly in contexts where excessive consumption of added sugars is linked to various chronic diseases. This trend has prompted the food industry to develop alternatives that maintain the sensory and functional characteristics of traditional spreads, but with a more balanced nutritional profile.

Partial or total replacement of sugar: technological and sensory implications

One of the primary strategies in creamer reformulation is the partial or total replacement of traditional sugars, such as sucrose, with non-caloric or low-calorie sweeteners. These include compounds such as stevia, aspartame, and erythritol, which provide sweetness without significant calories. The choice of an appropriate sweetener depends on factors such as thermal stability, interaction with other ingredients, and the sensory perception of the final product (Benedek et al., 2020).

Reducing the sugar content of creamers can affect their texture and stability. To counteract these effects, thickening and stabilizing agents such as gums, modified starches, and vegetable proteins are incorporated. These ingredients not only improve the product’s viscosity and stability but can also contribute to a mouthfeel more similar to traditional creamers (Dabo et al., 2024).

Consumer acceptance is crucial in the reformulation of products. Studies have shown that, although low-sugar creamers may differ in taste and texture compared to traditional versions, similar levels of acceptance can be achieved through the appropriate combination of sweeteners and texturizing agents. Sensory evaluation, using hedonic scales and preference analysis, is essential for optimizing formulations (Moebus et al., 2023).

From a nutritional perspective, reformulating low-sugar creamers can contribute to reducing calorie and added sugar intake in the diet, which is beneficial for preventing diseases such as obesity and type 2 diabetes. However, these reformulations must maintain an adequate nutritional balance, ensuring that the final product is not only low in sugar but also rich in essential nutrients (Onyeaka et al., 2023).

Impact of sugar reduction on texture, viscosity, sweetness, and shelf life

Reducing sugar content in food products, especially in gelled creams, is a trend that responds to public health demands and consumer preferences. However, this reduction entails significant technological challenges, as sugar not only provides sweetness but also significantly affects the product’s physical and sensory properties, as well as its storage stability.

Sugar plays a fundamental role in the structure formation of creams and gels by contributing to the formation of gel networks and the viscosity of the system. Reducing sugar can lead to a decrease in firmness and viscosity due to the lower concentration of soluble solids, which affects the product’s ability to retain water and maintain its consistency (Basu et al., 2017). To counteract these effects, hydrocolloids and gum blends are often used to compensate for the loss of texture and viscosity; however, the interaction between these additives and the rest of the ingredients must be carefully optimized to avoid adverse effects such as syneresis or an unpleasant texture (Yemenicioğlu et al., 2020).

Sugar is primarily responsible for the perception of sweetness in food products. Direct sugar reduction inevitably leads to a decrease in perceived sweetness, which can affect product acceptability. To maintain a satisfactory sensory profile, non-caloric or low-calorie sweeteners, such as stevia, erythritol, and maltitol, are used, providing sweetness without increasing caloric intake (Souza et al., 2022). However, the replacement of sugar with these compounds must be managed carefully to avoid residual or bitter flavors, and combining sweeteners is recommended to enhance palatability (Basu et al., 2017).

Sugar also contributes to product shelf life by reducing water activity, inhibiting microbial growth, and slowing down unwanted chemical reactions. Sugar reduction can increase product susceptibility to microbial proliferation and affect processes such as oxidation and the degradation of volatile compounds responsible for aroma (Nissa et al., 2019). Therefore, in low-sugar formulations, it is necessary to implement additional conservation strategies, such as the use of natural antimicrobial agents, pH control, and suitable packaging, to maintain microbiological and sensory stability during storage (Yemenicioğlu et al., 2020).

Hydrocolloids as alternative gelling agents

Hydrocolloids are natural polymers, primarily polysaccharides or proteins, widely used in the food industry for their functional properties, such as gelling, thickening, and stabilizing products. In the context of low-sugar food reformulation, hydrocolloids are particularly important because they can compensate for the loss of texture and viscosity resulting from sugar reduction, while also improving the stability of the final product.

The gelation mechanism of hydrocolloids is based on the formation of three-dimensional networks that trap large amounts of water, resulting in gels with distinct characteristics that depend on their molecular structure and processing conditions. Unlike traditional pectin, which requires high levels of sugar to form gels, many alternative hydrocolloids can form gels even in the absence of or at low concentrations of sugar (Gao et al., 2024).

Xanthan gum, guar gum, carrageenans, and alginates. Xanthan gum, a bacterial polysaccharide, is known for its high viscosity at low concentrations and its ability to form gels in combination with other polysaccharides, such as guar gum. The latter, extracted from seeds, acts as a thickener and stabilizer, and its combination with xanthan gum can significantly enhance the properties of the gel (Poret et al., 2021). For their part, carrageenans, derived from red algae, can form thermoreversible gels and present various structural variants (κ-, ι-, λ-carrageenans) that influence their gelling properties (García & Manriquez-Hernández, 2016). Alginates, derived from brown algae, form stable gels in the presence of calcium ions and are widely used in food products due to their versatility (Pournaki et al., 2024).

The use of these alternative hydrocolloids allows sugar to be reduced or eliminated in gelled products without losing texture or stability. It also enhances shelf life and sensory quality, enabling the development of foods with improved nutritional profiles for consumers seeking healthier options. However, their application requires detailed knowledge of their physicochemical properties and their interactions with other ingredients, as inadequate dosage or incorrect combination can negatively affect the texture, sensory perception, and stability of the final product (Poret et al., 2021).

Xanthan gum: structure, properties, and food applications

Xanthan gum is an extracellular polysaccharide produced by the bacterium *Xanthomonas campestris* through fermentation. Its unique chemical structure and functional properties have made it one of the most important and versatile hydrocolloids in the food industry.

Xanthan gum has a primary structure of a heteropolysaccharide polymer composed of a linear glucose backbone similar to cellulose, with lateral branches formed by disaccharides composed of mannose and glucuronic acid. These branches confer a helical structure in aqueous solution, which determines their high thickening and stabilizing power (Asase & Glukhareva, 2023). The presence of carboxyl and pyruvate groups in the structure provides a negative charge, which favors electrostatic interactions with other molecules and enhances its solubility in water (Chaturvedi et al., 2021).

Xanthan gum is characterized by its high viscosity even at low concentrations, stability against changes in pH, temperature, and ionic strength, and ability to form gels when combined with other hydrocolloids, such as guar gum or carrageenan (Schreiber et al., 2020). Furthermore, it exhibits thixotropic properties, meaning its viscosity decreases under shear stress, facilitating the handling and processing of food products containing it.

Xanthan gum is primarily used as a thickening, stabilizing, and gelling agent. It is widely used in dairy products, sauces, dressings, beverages, bakery products, and low- or no-sugar foods, where it helps maintain the desired texture and stability without the need for large amounts of sugar (Asase & Glukhareva, 2023). Its ability to form gels without heat makes it especially useful in heat-sensitive formulations. Furthermore, its resistance to enzymatic degradation makes it an excellent candidate for enhancing product shelf life (Asase & Glukhareva, 2023).

Another relevant application is its use in dietary products and for individuals with special needs, as it is a non-caloric and non-digestible ingredient that contributes to total dietary fiber and promotes intestinal health (Chaturvedi et al., 2021).

Locust bean gum (LBG): structure, properties, and food applications

Locust bean gum, known as Locust Bean Gum (LBG), is a natural polysaccharide extracted from the seeds of the carob tree (*Ceratonia siliqua*). Due to its functional properties, LBG is one of the most widely used hydrocolloids in the food industry to improve the texture, stability, and viscosity of various products.

The chemical structure of locust bean gum is primarily composed of the polysaccharide galactomannan. Its backbone is a linear polymer of β-(1→4)-D-mannose, with α-(1→6)-D-galactose branches at approximately every four to six mannose residues. This structure gives it hydrophilic characteristics and the ability to form viscous solutions upon hydration (Romero-Martínez et al., 2025). The ratio of mannose to galactose varies depending on the source and extraction method, which in turn influences the gum's functional properties.

Locust bean gum is noted for its high thickening and stabilizing capacity, as well as for its synergy with other hydrocolloids, such as xanthan gum and carrageenan, with which it can form firmer and more elastic gels (Saha et al., 2010). It is insoluble in alcohol and remains stable over a wide range of pH values and temperatures, making it highly versatile for various applications. Furthermore, LBG exhibits a low tendency to syneresis formation, improving water retention in food products (Gao et al., 2024).

In the food industry, locust bean gum is used as a thickening, stabilizing, and gelling agent in products such as ice cream, dairy products, sauces, baked goods, and diet foods. Its ability to improve the texture and stability of low-fat or low-sugar products is particularly valued (Saha et al., 2010). Furthermore, its combination with xanthan gum is common to improve rheological and sensory properties, as together they form synergistic gels that provide adequate texture and viscosity to reformulated products for sugar reduction (Romero-Martínez et al., 2025).

On the other hand, locust bean gum is a natural and non-toxic ingredient recognized for its minimal impact on human health, and it can contribute to the dietary fiber content of foods, promoting intestinal health (Gao et al., 2024).

Synergy between gums: xanthan-carob interaction in gelled systems

Xanthan gum and locust bean gum (LBG) in gelled systems are a well-documented phenomenon that generates remarkable synergistic effects on gel texture. The combination of these two gums produces gels with greater firmness and elasticity compared to those formed by each gum individually (Poret et al., 2021). This synergy is attributed to the specific interaction between the linear mannose chains of locust bean gum and the helical structure of xanthan gum, resulting in the formation of a more organized and resistant three-dimensional network (Williams & Phillips, 2008).

Xanthan-carob synergy also improves the stability of gelled systems. The more compact and stable molecular network prevents phase separation and syneresis, thereby maintaining product homogeneity during storage and under various environmental conditions (García & Manriquez-Hernández, 2016). This characteristic is essential in food products where texture and visual appearance must be preserved to ensure consumer acceptance.

In terms of viscosity, the blend of xanthan gum and locust bean gum exhibits non-additive behavior, where the combined viscosity exceeds the sum of the individual viscosities of each gum (Poret et al., 2021). This increased viscosity is beneficial for enhancing the mouthfeel and stability of emulsions and suspensions, as it helps maintain the dispersion of components and prevents sedimentation (Williams & Phillips, 2008).

The water-binding capacity of gelled systems is another key benefit of the synergy between xanthan and carob. The gel structure formed by the interaction of both gums effectively retains water, which reduces syneresis and improves the juicy, fresh texture of the products (García & Manriquez-Hernandez, 2016). This property is crucial in foods such as gelled creams, yogurts, and desserts, where a moist texture is desirable.

This synergy is commonly exploited in the reformulation of low-sugar or low-fat foods, where it is necessary to compensate for the loss of texture and stability caused by the reduction of these components. Furthermore, these combinations enable the design of products with specific functional characteristics, adapting to sensory and nutritional requirements without compromising quality (Poret et al., 2021).

Technological applications of gums in fruit products

Natural gums, such as xanthan gum, locust bean gum, guar gum, carrageenan, and alginates, are hydrocolloids widely used in the food industry to improve the technological and sensory properties of fruit-derived products. Their use is crucial in the formulation of gel-textured products, such as juices, jams, jellies, and fruit creams, where they contribute to stability, texture, and shelf life.

Gums act as thickening and gelling agents, improving the texture of fruit products by increasing viscosity and forming three-dimensional networks that retain water. For example, xanthan gum and locust bean gum are frequently combined to produce firm, consistent gels in jams and fruit spreads, especially when reducing sugar content is desired without compromising texture (Gao et al., 2024). These gums help maintain a homogeneous texture and prevent phase separation during storage.

One of the challenges in fruit-based gel products is syneresis, or the loss of water, which affects both appearance and texture. Gums enhance the water-holding capacity of these products, minimizing syneresis and prolonging freshness and juiciness (Poret et al., 2021). This is critical for maintaining the sensory quality of products such as jellies and gelled creams throughout their shelf life.

The stabilizing properties of gums also contribute to the shelf life of fruit products by improving physical and chemical stability. For example, by increasing viscosity and reducing the mobility of free water, microbial growth and the degradation of sensitive components are inhibited, favoring the preservation of color, flavor, and aroma (Schreiber et al., 2020).

With the growing demand for healthy products, gums are used to reformulate fruit products with low sugar or fat content, compensating for the loss of texture and body that these changes entail (García & Manriquez-Hernandez, 2016). Their use allows the development of attractive and functional products, maintaining consumer acceptance. Thus, in jams and jellies, gums enable the achievement of the desired texture without the need for high concentrations of sugar or pectin, thereby facilitating the production of dietary versions (Gao et al., 2024). In gelled creams, the combination of xanthan gum and locust bean gum provides the characteristic semi-solid texture with improved stability (Poret et al., 2021). In juices and nectars, they improve the suspension of solids and stability against sedimentation, maintaining a uniform appearance (Schreiber et al., 2020).

Studies on gelled fruit products (jams, jellies, creams)

Gelled fruit products, such as jams, jellies, and creams, have been the subject of numerous studies due to their commercial importance and the growing demand for healthier formulations, such as those low in sugar or containing functional ingredients. These studies address technological, sensory, nutritional, and stability aspects to optimize the quality and acceptance of these foods.

Several researchers have explored reducing sugar content in jams and jellies by using alternative gelling agents, such as hydrocolloid blends, to maintain their textural properties. For example, Massoud et al. (2018) investigated the incorporation of xanthan gum and guar gum combinations to partially replace pectin and sugar in tropical fruit jams, resulting in an adequate texture and increased sensory acceptance. Similarly, Zoulias et al. (2000) evaluated the partial replacement of sucrose with polyols in fruit jellies, observing improvements in the glycemic profile without compromising the gel's viscosity or firmness.

The studies by Pereira et al. (2013) focused on evaluating the rheological and sensory properties of guava gelled creams with different concentrations of sugar and gelling agents, concluding that the interaction between gums significantly influences the texture and sweetness perception. Similarly, Morais et al. (2022) analyzed the influence of soluble solids concentration on the texture and stability of jams, emphasizing the importance of controlling this parameter to prevent syneresis.

Some studies have incorporated functional ingredients, such as natural extracts rich in phenolic compounds, to enhance the nutritional value and shelf life of gelled products (Kawee-ai, 2025). The literature also highlights the challenges associated with reformulating these products, such as syneresis, loss of firmness, and changes in sensory profile. To address these challenges, the combination of different hydrocolloids and the use of innovative processing techniques have been proposed (Alam et al., 2025). Furthermore, assessing microbiological and chemical stability is essential to ensure safety and quality throughout the shelf life.

Efficiency of gum blends in reduced sugar formulations

Reducing sugar content in food products is a growing trend due to health concerns and the control of diseases related to excessive sugar consumption, such as obesity and diabetes. However, reducing sugar can negatively affect the texture, viscosity, sweetness, and stability of gelled products. In this context, gum blends (hydrocolloids) have proven to be an effective strategy for compensating for these losses and maintaining the sensory and functional quality of the products.

Gum blends, such as the combination of xanthan gum with guar gum or locust bean gum, exhibit synergistic effects that enhance gel formation and viscosity compared to the individual use of each gum (Poret et al., 2021). This synergy is attributed to the specific interactions between the polysaccharide chains, which facilitate the formation of a more stable and dense three-dimensional network capable of retaining water and imparting an adequate texture, even in formulations with low sugar content.

Studies have shown that gum blends can restore or even improve the rheological properties of reduced-sugar products, generating viscosities and firmness similar to those of conventional versions (Gao et al., 2024). For example, Asase and Glukhareva (2023) reported that, in reduced-sugar gelled creams and jams, the combination of xanthan gum and locust bean gum maintained the desired semi-solid texture and mouthfeel, without altering the sweetness perception.

In addition to textural improvements, gum blends enhance the physical stability of the product, reducing syneresis and preventing phase separation, which are critical aspects in formulations with lower sugar content (García & Manriquez-Hernández, 2016). This contributes to extending shelf life and preserving sensory quality during storage.

The application of gum blends has been successfully adopted in various food products, including jams, jellies, gelled creams, and yogurts, where sugar reduction is sought without compromising texture or stability (Poret et al., 2021). This approach is key to the development of functional and dietary foods that meet current market demands.

Comparison with pectin and other hydrocolloids

Pectin is one of the most traditional and widely used hydrocolloids in the food industry, especially in the production of fruit-based gels such as jams and jellies. However, the growing demand for formulations with reduced sugar and new functional profiles has driven the search for alternatives, such as xanthan gum and locust bean gum, as well as other hydrocolloids, which offer different technological properties.

Pectin is a polysaccharide composed primarily of homogalacturonan chains that form gels in the presence of high levels of sugar and under acidic pH conditions. This requirement limits its use in low-sugar products, as the absence of sugar negatively affects gel formation and stability (Gao et al., 2024). In contrast, xanthan gum and locust bean gum can form stable gels at low levels or even in the absence of sugar, thanks to their rheological properties and their ability to form networks without requiring sugar or strict acidic conditions (Onyeaka et al., 2023).

While pectin gels typically exhibit a firm, brittle texture, combinations of gums, such as xanthan and carob gums, provide gels with greater elasticity and resistance to syneresis (Poret et al., 2021). Furthermore, gels formed by gum blends tend to be more resistant to changes in temperature and pH, thereby providing greater stability under various processing and storage conditions (García & Manriquez-Hernández, 2016).

Pectin is especially valued in traditional products that require a specific texture and characteristic flavor, but its dependence on sugar limits its use in dietary formulations. On the other hand, alternative hydrocolloids, such as xanthan gum and locust bean gum, are preferred for the production of low-sugar products, as they allow for the adjustment of viscosity and texture without compromising stability or palatability (Gao et al., 2024). However, some hydrocolloids can alter sensory perception or require combinations to avoid undesirable effects such as off-flavors or excessively viscous textures.

The synergy between different hydrocolloids has been widely studied to optimize functional properties. For example, blending xanthan gum and carob gum produces gels with superior characteristics than either of them alone. At the same time, the addition of pectin can modulate texture and provide specific gelation properties (Poret et al., 2021). This strategy allows formulations to be tailored to specific needs, combining the advantages of each hydrocolloid.

Advances in the development of low-sugar gel creams

In recent years, the growing demand for products with lower sugar content has driven research aimed at developing guava gels that maintain their sensory and functional characteristics while minimizing the use of added sugars.

One of the most widely used strategies for reducing sugar in guava gelled creams has been the partial or total replacement of traditional sugar and pectin with hydrocolloid blends, such as xanthan gum and locust bean gum. These blends have been shown to improve the texture, viscosity, and stability of the final product, compensating for the loss of body and sweetness that sugar reduction entails (Onyeaka et al., 2023). Furthermore, these gums enable adequate water retention, preventing syneresis during storage (Poret et al., 2021).

Several studies have investigated the optimization of technological parameters, including soluble solids concentration, cooking time, and temperature, to achieve the optimal texture and stability of low-sugar gelled creams. For example, Pereira et al. (2013) evaluated the effect of gum and soluble solids concentration on the firmness and stability of guava creams, reporting that adjustments to these parameters allow for an acceptable semi-solid texture with reduced sugar levels.

Additionally, the incorporation of functional ingredients, such as antioxidant extracts and prebiotics, has been explored. These not only improve the nutritional profile but also contribute to the product's stability and shelf life (Ramírez et al., 2023). This responds to the growing trend toward healthy and functional products that provide benefits beyond basic nutrition.

Sensory acceptance is a critical aspect in the development of low-sugar gelled creamers. Recent sensory studies suggest that formulations combining alternative hydrocolloids and natural sweeteners can achieve levels of acceptance comparable to those of conventional products, provided that texture and sweetness are adjusted appropriately (Zoulias et al., 2000).

Research on specific formulations

In the ongoing quest to enhance the quality and functionality of food products, specific formulations have gained prominence in recent research, particularly in the development of foods with nutritional profiles tailored to current consumer demands, such as reduced sugar content, the inclusion of functional ingredients, and improved sensory properties.

Several studies have focused on the design of specific formulations for gelled products such as creams, jams, and jellies, with special emphasis on reducing sugar content without compromising texture or stability. Asase and Glukhareva (2023) developed gelled cream formulations with blends of xanthan gum and locust bean gum, achieving a semi-solid texture and adequate sensory properties in products with reduced sugar content. These studies also involve optimizing hydrocolloid concentrations to balance viscosity and sweetness.

The inclusion of functional ingredients, such as antioxidant extracts, prebiotics, or natural sweeteners, has been the subject of research aimed at enhancing the nutritional and sensory value of specific products. Ramírez et al. (2023) evaluated the addition of hibiscus extract to citrus jellies, finding improvements in antioxidant activity and color preservation. These advanced formulations respond to healthy consumption trends and seek to add functional value.

The combination of different hydrocolloids to obtain superior functional properties has been widely explored. Poret et al. (2021) analyzed formulations with blends of xanthan gum and guar gum, demonstrating synergistic effects that improve viscosity, texture, and stability in gelled products. These investigations highlight the importance of adjusting the proportions of each hydrocolloid to obtain an optimal balance in specific formulations.

Consumer acceptance remains a determining factor. Zoulias et al. (2000) studied sugar-reduced jelly formulations using polyols and gums, concluding that sensory acceptance can be maintained through the appropriate use of hydrocolloids and natural sweeteners. This type of research combines technical analysis with sensory testing to ensure the commercial viability of products.

Rheological, sensory, and stability evaluation

The comprehensive evaluation of gelled food products, such as creams, jams, and jellies, requires the simultaneous analysis of their rheological, sensory, and stability properties to ensure the quality, acceptance, and shelf life of the final product. Rheological characterization is essential for understanding the behavior of gelled products under various stress and deformation conditions. Techniques such as viscosity, elasticity, and viscoelasticity analysis determine the internal structure and strength of the gel, which are factors that directly influence texture and mouthfeel (Onyeaka et al., 2023). The evaluation of parameters such as the storage modulus (G') and the loss modulus (G'') allows for distinguishing between more elastic or viscous behaviors, which is essential for adjusting formulations in low-sugar products (Poret et al., 2021).

Sensory evaluation complements technical analysis by providing information on consumer acceptance and organoleptic preferences. Trained panels or consumers are used to evaluate attributes such as texture, sweetness, flavor, aroma, and appearance (Zoulias et al., 2000). In products reformulated to reduce sugar, this evaluation is critical to ensure that technological changes do not compromise the sensory experience and product acceptability.

The physical and chemical stability of gelled products is crucial for maintaining their characteristics throughout their shelf life. Syneresis, phase separation, and loss of firmness are commonly used to evaluate gel integrity over time (García & Manriquez-Hernández, 2016). Additionally, changes in color, pH, and water activity are assessed, which can influence the microbiological and sensory preservation of the product (Gao et al., 2024).

The combination of these evaluations enables formulation optimization, particularly in low-sugar products, where the loss of functional and sensory properties must be compensated for. Recent research has demonstrated that fine-tuning hydrocolloid blends and processing parameters can achieve an optimal balance between texture, flavor, and stability (Onyeaka et al., 2023).

Comparative analysis between pectin and xanthan gum systems - carob

Gelling systems based on pectin and blends of xanthan gum and locust bean gum are two widely used approaches in the food industry for producing gelled products, especially those derived from fruits. The choice between these systems depends on the desired functional properties, the type of product, and the processing conditions.

Pectin is a natural polysaccharide that forms gels in the presence of high sugar levels and acidic conditions, which limits its application to products with low sugar content or near-neutral pH (Gao et al., 2024). Its gelation relies on the interaction of homogalacturonan chains and the presence of calcium or sugar to form a firm, three-dimensional network.

A xanthan gum and locust bean gum-based system works through synergistic interactions that allow the formation of stable gels at different pH levels and without the need for high sugar concentrations (Onyeaka et al., 2023). Xanthan gum provides viscosity and stability, while locust bean gum contributes to the formation of firmer and more elastic gelling networks.

Pectin gels have a firm yet fragile texture, characterized by a rigid structure but with reduced elasticity (Poret et al., 2021). On the other hand, gels formed by mixing xanthan gum and carob gum tend to be more elastic and resistant, with a greater capacity to recover their shape after deformation, which improves mouthfeel and consumer acceptance (García & Manriquez-Hernández, 2016). Rheologically, xanthan -carob systems exhibit a more balanced viscoelastic behavior, with higher storage modulus (G') values, which indicates a greater capacity to maintain the structure under mechanical stress (Onyeaka et al., 2023).

Xanthan-carob systems exhibit lower syneresis compared to pectin gels, due to their greater ability to retain water and form more cohesive matrices (Gao et al., 2024). This results in improved physical stability and extended shelf life in products formulated with these gums. While pectin is ideal for traditional high-sugar products, such as classic jams, the xanthan-carob system is preferred in modern, dietary, or low-sugar products, where stable, well-textured gels are required without relying on high sugars (Poret et al., 2021). However, sensory perception may vary, as some consumers detect differences in texture and mouthfeel between the two systems, which should be evaluated in sensory studies.

Technological challenges and perspectives

The development of innovative food products, such as low-sugar guava gels, faces multiple technological challenges that must be overcome to meet both market demands and current nutritional and sensory requirements. Despite advances in formulation and the use of alternative hydrocolloids, challenges remain, motivating continued research and development in this area.

One of the main challenges is maintaining product texture and stability after sugar reduction, a key component in the formation of traditional gels such as those based on pectin (Gao et al., 2024). The reduction in sugar affects firmness, viscosity, and sweetness perception, making it necessary to optimize the combination and concentration of alternative gelling agents such as xanthan and locust bean gums to compensate for these losses (Onyeaka et al., 2023).

Furthermore, ensuring microbiological and sensory stability during storage is another significant challenge, especially when incorporating functional or natural ingredients that can alter the product's chemical profile (García & Manriquez-Hernández, 2016). Syneresis, color degradation, and flavor loss are common problems that require advanced formulation and preservation techniques.

The trend toward healthier and more sustainable formulations is driving the development of new technologies, including the use of synergistic blends of hydrocolloids, the application of non-thermal processing and preservation technologies, and the incorporation of functional ingredients that provide additional benefits (Poret et al., 2021). Nanotechnology and encapsulation of bioactive compounds also offer prospects for improving the stability and controlled release of flavors and nutrients.

The use of computational tools and predictive modeling in formulation enables more efficient optimization of rheological and sensory properties, facilitating the design of products with specific characteristics tailored to consumer needs (Zoulias et al., 2000).

These technological advances not only contribute to diversifying the supply of low-sugar products but also allow us to respond to the growing demand for functional foods with improved sensory properties. However, consumer acceptance will largely depend on the ability to balance attributes such as texture, sweetness, and nutritional value, which requires close collaboration among researchers, technologists, and the manufacturing sector (Onyeaka et al., 2023).

Technical and economic limitations of the use of alternative hydrocolloids

Xanthan gum, locust bean gum, guar gum, and other polysaccharides have gained prominence in the food industry for the development of products with specific characteristics, such as sugar reduction in gelled creams and other processed foods. However, their implementation presents technical and economic limitations that must be considered for their successful application.

One of the main technical limitations is the variability in the functional properties of hydrocolloids, which can depend on their origin, purity, and extraction methods (Gao et al., 2024). This variability affects the reproducibility and consistency of final products, complicating the standardization of industrial processes. Furthermore, some alternative hydrocolloids can interact undesirably with other ingredients, altering the texture, viscosity, or even the flavor of the product. For example, certain combinations can produce excessively viscous textures or fragile gels, which fail to meet consumer sensory expectations (Onyeaka et al., 2023). Another challenge is the sensitivity of some hydrocolloids to processing conditions, such as pH, temperature, and ionic strength, which can impact gel formation and stability (García & Manriquez-Hernández, 2016). This demands rigorous control of technological parameters to ensure product quality.

From an economic perspective, the production and acquisition costs of alternative hydrocolloids are often higher than those of traditional ingredients, such as sugar and pectin (Poret et al., 2021). This can increase the final cost of the product, limiting its competitiveness in price-sensitive markets. Furthermore, the need for more complex formulations and the use of hydrocolloid blends to compensate for the properties lost by reducing sugar entails higher costs in research, development, and process validation, as well as in the training of technical personnel.

To overcome these limitations, progress is needed in the development of more efficient and sustainable extraction technologies, as well as in the detailed study of the interactions between hydrocolloids and other ingredients (Zoulias et al., 2000). Formulation optimization and the use of modeling technologies can contribute to cost reduction and improved quality. Although alternative hydrocolloids offer significant advantages for formulating low-sugar products, their technical and economic limitations must be carefully managed to maximize their industrial and commercial potential.

Innovation potential in the functional food industry

The functional food industry represents a rapidly expanding sector that combines nutrition and health, responding to the growing demands of consumers concerned with well-being and disease prevention. Innovation plays a crucial role in the development of products that not only meet basic nutritional needs but also offer specific health benefits, such as immune system enhancement, metabolic control, and the prevention of chronic diseases.

The potential for innovation lies in the development and application of advanced technologies such as nanotechnology, bioactive encapsulation, and biotechnology, which improve the bioavailability, stability, and controlled release of functional compounds (Su et al., 2023). Furthermore, the exploration of new ingredients, such as prebiotic fibers, natural antioxidants, bioactive peptides, and probiotic microorganisms, expands the functional portfolio available for innovative formulations (Câmara et al., 2020).

Another area of innovation is personalized nutrition, where food products are tailored to the specific needs of individuals or groups based on their genetics, microbiota, or lifestyle. This trend necessitates the development of functional foods with customizable profiles, promoting the use of versatile ingredients and technologies that enable the adjustment of nutritional and sensory properties (Donovan et al., 2025).

The need for sustainability also drives innovation in functional foods. Leveraging agro-industrial byproducts as sources of bioactive compounds and functional fibers has become a key strategy for developing novel ingredients, reducing waste, and improving the circular economy within the food sector (Saini et al., 2025). These practices not only provide added value but also respond to the demands of consumers who are conscious of their environmental impact.

Despite its great potential, the industry faces regulatory, technological, and consumer acceptance challenges that limit the rapid adoption of innovations. Interdisciplinary research, collaboration between academia and business, and consumer education are key elements in overcoming these barriers and achieving sustainable and prosperous development (Bigliardi & Galati, 2013).

In conclusion, the potential for innovation in the functional food industry is broad and multifaceted, offering significant opportunities to enhance public health and provide differentiated products that address current consumer and sustainability trends.

Trends in clean labeling, healthy foods, and responsible consumption

Today, trends in the food industry reflect a growing consumer demand for products that are perceived as more natural, healthy, and sustainable. Three key concepts guiding this transformation are clean labeling, healthy food production, and the promotion of responsible consumption, which impact both the formulation and marketing of food products.

Clean labeling refers to the practice of using simple, recognizable, and minimally processed ingredients, avoiding artificial additives and synthetic preservatives. This trend responds to the modern consumer's desire for transparency and trust in the food they consume (Grant et al., 2021). Recent studies have shown that clean labeling significantly influences quality perceptions and purchase intentions, motivating companies to reformulate their products to meet these standards (Chang & Chen, 2022).

The demand for healthy foods is linked to a growing awareness of chronic disease prevention and the importance of overall well-being. This is driving product reformulation to reduce harmful ingredients, such as sugars, sodium, and saturated fats, and increase functional components, including fiber, antioxidants, and high-quality proteins (Onyeaka et al., 2023). The combination of clean labeling with functional attributes promotes products that provide additional benefits, aligning with the recommendations of international health organizations (WHO, 2020).

Responsible consumption involves not only choosing healthy foods but also considering the environmental and social impact of production and consumption. Consumers are increasingly valuing sustainable practices, such as using locally sourced ingredients, organic production, and waste reduction (Migliore, 2021). This trend has led companies to adopt circular economy and social responsibility strategies, integrating these values into the food value chain (Grunert, 2011).

Integrating these trends represents a challenge for the industry, which must balance technological innovation, economic viability, and consumer acceptance. Consumer education and transparent regulation are key elements in promoting informed and responsible consumption practices (Al-Nuaimi et al., 2022).

Trends in clean labeling, healthy foods, and responsible consumption are transforming the food landscape, promoting more transparent, nutritious, and sustainable products that respond to the demands and values of contemporary consumers.

Conclusions

The development of low-sugar gelled fruit products represents an innovative strategy that aligns with current demands for responsible consumption, clean labeling, and healthy eating. In this context, alternative hydrocolloids such as xanthan gum and locust bean gum (LBG) have shown great potential as gelling agents, significantly improving the texture, stability, and rheological characteristics of low-sugar formulations, even in synergistic combinations that surpass, in some cases, the performance of traditional pectin. Recent research supports their efficacy in products such as guava creams, also contributing to the nutritional and sensory functionality of foods. However, their adoption faces technical and economic challenges, particularly related to standardization, availability, and cost of industrial implementation. Despite these limitations, the use of natural hydrocolloids presents a significant opportunity for innovation in the functional food industry, promoting healthier and more sustainable formulations that contemporary consumers are likely to accept.

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Conflicts of interest

The author declares that he has no conflict of interest.

Author contributions

Conceptualization: Zulema Llorente-Romero. **Formal analysis:** Zulema Llorente-Romero, Edwin F. Cerda. **Research:** Zulema Llorente-Romero, Edwin F. Cerda. **Methodology:** Zulema Llorente-Romero. **Visualization:** Zulema Llorente-Romero, Edwin F. Cerda. **Writing the original draft:** Zulema Llorente-Romero, Edwin F. Cerda. **Writing, review, and editing:** Zulema Llorente-Romero, Edwin F. Cerda.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Statement on the use of AI

The authors acknowledge the use of generative AI and AI-assisted technologies to improve the readability and clarity of the article.

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