Food Science and Engineering
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Review

A Review of the Effect of Adding Fat Substitutes on the Shelf Life and Quality Characteristics of Bakery Products

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Received: 27 August 2025; **Revised:** 21 November 2025; **Accepted:** 28 November 2025

Abstract: Fat substitutes are increasingly used in bakery products to reduce saturated and trans fat intake while maintaining sensory and structural properties. This review summarizes recent advances in carbohydrate-based (e.g., inulin, polydextrose), protein-based (e.g., whey protein, amaranth flour), and structured fat replacers (e.g., oleogels, emulsion-filled gels) and their effects on texture, moisture retention, oxidative stability, and shelf life. Oleogels and emulsion-based systems significantly lower saturated and trans fats, enhance oxidative stability, and reduce mold growth, while carbohydrate-based replacers improve moisture retention but may increase hardness or reduce volume at high substitution levels. Protein-based substitutes enhance nutritional value through increased fiber and antioxidants but can introduce off-flavors or allergen risks. Emulsifiers and hydrocolloids delay staling, retain moisture, and extend shelf life by up to 12 weeks without microbial growth. However, complete fat replacement often compromises texture, flavor, and consumer acceptance. Partial substitution (up to 75%) consistently yields better sensory and quality outcomes than full replacement. Formulation complexity and consumer preference remain key challenges. Ongoing research is needed to optimize fat replacer combinations and improve processing techniques to balance health benefits with sensory appeal and industrial feasibility.

***Keywords*:** bakery products, fat substitutes, shelf life

1. Introduction

Reducing fat in bakery products is crucial for addressing health concerns, meeting consumer demand, and maintaining product quality. High fat intake, particularly from saturated and trans fats, is linked to chronic diseases such as obesity and cardiovascular issues, prompting the need for low-fat alternatives [1, 2]. As consumers become more health-conscious, there is a growing market for reduced-fat products, leading manufacturers to explore fat substitutes and reformulate recipes without compromising taste and texture [3, 4]. Innovative approaches, such as using oleogels or other fat replacers, can help maintain the desirable sensory attributes of baked goods while lowering fat content [5, 6]. Maintaining quality in low-fat bakery products poses several challenges, primarily related to texture, flavor, shelf life, and ingredient limitations. The reduction of fat can lead to a dry or crumbly texture, negatively impacting consumer acceptance [7]. Additionally, fat is essential for flavor development, and low-fat products may lack the richness expected

DOI: https://doi.org/10.37256/fse.7120268406

by consumers [2, 3]. Furthermore, these products often have shorter shelf lives due to increased staling and moisture loss, which can affect freshness [8]. Addressing these challenges requires innovative formulation strategies to meet consumer expectations.

Although numerous studies have evaluated individual fat replacers (carbohydrate-based, protein-based, oleogels, and emulsion/gels), there remain clear gaps that limit practical application. First, comparative syntheses that align replacement type with specific product classes (e.g., sponge cake vs. shortbread) are sparse, making it difficult for formulators to generalize findings. Second, economic and regulatory aspects (costs of oleogelators, novel-food approvals, clean-label constraints) are rarely discussed alongside technical performance. Third, there is limited evidence on hybrid strategies that combine proteins, hydrocolloids, and structured oils to balance texture, shelf life, and consumer acceptance. Finally, standardized sensory and shelf-life protocols across studies are lacking, which hampers cross-study comparisons. To address these gaps, this review (i) synthesizes primary research on fat replacers by product category, (ii) evaluates effects on shelf life and quality with a comparative table, and (iii) highlights economic, regulatory, and sensory-assessment priorities to guide future research and industrial adoption.

2. Fat substitutes in bakery products

Fat substitutes in bakery products are gaining attention due to rising health concerns and consumer demand for lower-fat options. Various strategies have been developed to replace or reduce fat content while maintaining desirable sensory attributes. Gutiérrez-Luna et al. reviewed the application of structured fat replacers, including hydrogels, emulgels, and oleogels, in bakery products to reduce fat content while maintaining product quality. The review highlighted the use of oils rich in monounsaturated fatty acids, such as olive and canola oils, with oleogelation as a key structuring technique utilizing stabilizers like waxes and fibers. Fat substitutes were shown to enhance the nutritional profile of bakery products while preserving sensory attributes. However, oils high in polyunsaturated fatty acids presented oxidative stability challenges, which were often mitigated through the addition of antioxidants. The findings suggested that partial fat replacement (up to 75%) was more effective in maintaining product quality and consumer acceptance than complete substitution. The review concluded that gel-based fat replacers provide promising alternatives for healthier bakery products, though careful formulation is required to optimize shelf life and storage stability [9]. Oleogels are one of the most promising alternatives, created by structuring oils with agents like Hydroxypropyl Methylcellulose (HPMC) and xanthan gum. Research indicates that oleogels can replace traditional fats like shortening, achieving reductions in saturated fats by up to 52.46% and trans fats by 75.72% without compromising the quality of products such as pan bread [10]. Carbohydrate-based fat replacers such as inulin, polydextrose, and maltodextrin have also been investigated. These substitutes can enhance moisture retention and improve textural properties in products like muffins and traditional pastries. However, complete fat replacement may lead to undesirable qualities, such as increased toughness and reduced volume [11]. Protein-based substitutes, such as whey protein and amaranth flour, enhance the nutritional profile of baked goods. For instance, amaranth flour has been shown to increase protein and fiber content while improving antioxidant activity in products like crackers and tortillas [12].

2.1 *Mechanisms of action*

In a study conducted by Kanjilal et al. and in the chapter "Baked Products", the mechanisms of action for fat substitutes in baked goods were highlighted. These substitutes, such as oleogels and structured lipids, mimic the mouthfeel and structural integrity of traditional fats, aiding in the maintenance of crumb structure and moisture retention [13, 14]. Additionally, structured lipids have melting profiles similar to traditional fats, ensuring comparable flavor and aroma release. Nutritionally, substitutes like Microcrystalline Cellulose (MCC) and egg white not only reduce fat content but also enhance the nutritional profile by increasing fiber and protein content [15].

In a study conducted by Nazari et al. and Serin et al., the effects of fat substitutes on dough properties and final product characteristics in baked goods were comprehensively analyzed. The incorporation of fat replacer gels containing whey protein concentrate and maltodextrin was found to increase dough viscosity and specific density compared to control samples. In traditional products like pogaca, the use of carbohydrate-based fat replacers led to increased dough stickiness and changes in extensibility, affecting dough handling properties [16, 17]. Regarding final product characteristics, cakes made with fat replacer gels maintained similar hardness and sensory attributes to full-fat control samples, despite significant fat reduction [16]. In biscuits, the inclusion of cellulose emulsions and inulin did not negatively impact sensory evaluations, even with substantial fat reductions [18, 19]. Optimal formulations resulted in higher cake volumes and moisture content, demonstrating the potential of fat substitutes to enhance product quality [16]. However, Krystyjan et al. noted that excessive fat substitution might cause undesirable textural changes, such as increased hardness or diminished sensory appeal, particularly at higher substitution levels [18]. Fat substitutes influence food properties by modifying texture, mimicking fat-derived flavors, altering physicochemical stability, and impacting consumer acceptance. They can increase hardness, affect water-holding capacity, and enhance or challenge sensory qualities. While protein-based substitutes offer lower calories, they may introduce undesirable flavors or allergenic risks. Balancing sensory appeal, stability, and nutritional benefits is crucial for developing successful low-fat food products [20]. Figure 1 illustrates the multifaceted mechanisms of fat replacers, including texture modification, flavor mimicry, and physicochemical stabilization (adapted from Gao et al. [20]).

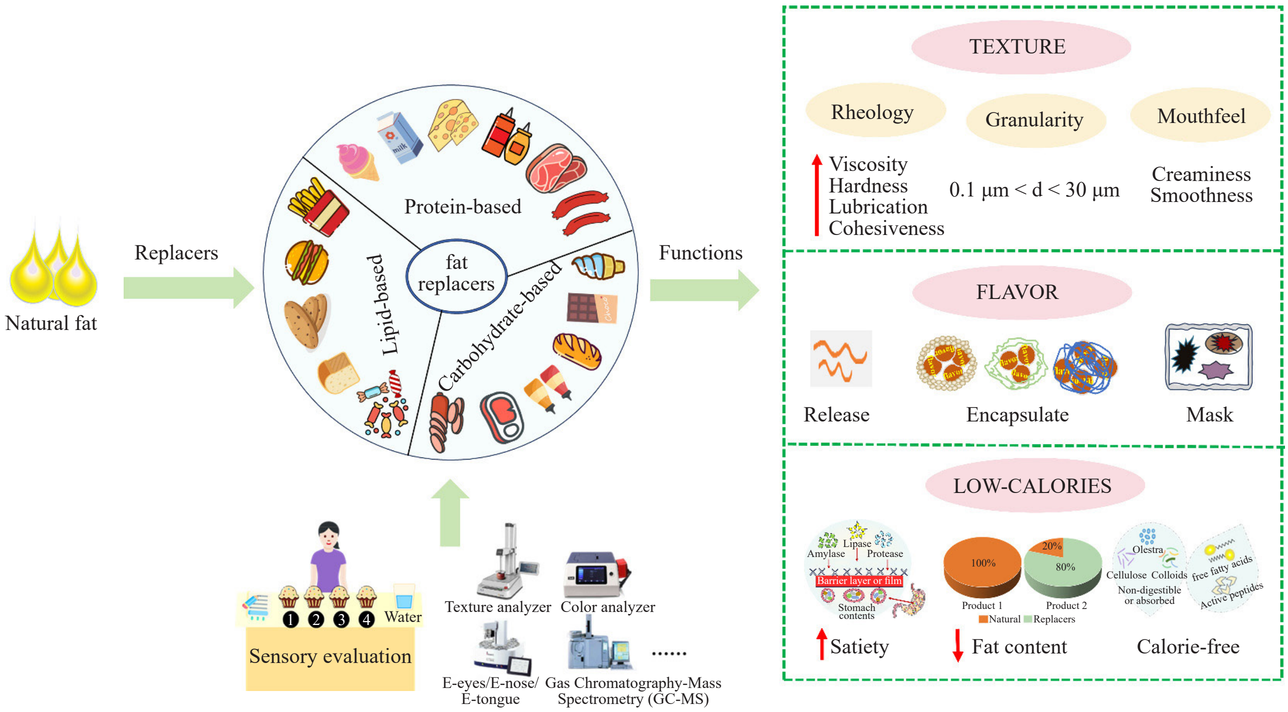

Figure 1. Mechanisms of action for fat substitutes in baked goods [20]

Table 1. The functional characteristics of fat replacers in bakery

Replacer Type	Mechanism	Example	Effect on Texture	Effect on Shelf Life	Ref.
Oleogel/Structured lipid	Oil structuring + similar melting profile	HPMC-based oleogel, structured lipids	Maintains softness, mimics mouthfeel, supports crumb structure	Improves oxidative stability, delays rancidity	[13, 14]
Carbohydrate-based gel	Increases dough viscosity and water-binding	Whey protein concentrate + maltodextrin gel	Higher density, potential hardness at high levels	Delays staling via moisture retention	[16, 18]
Carbohydrate-based (inulin, cellulose)	Water entrapment, viscosity increase	Inulin in biscuits, cellulose emulsions	May increase hardness or reduce volume	Extends moisture stability	[17, 18]
Protein + hydrocolloid gel	Emulsification, aeration, foam stabilization	Whey + maltodextrin in cake	Maintains volume, reduces chewiness	Stabilizes structure over time	[16]

Table 1 synthesizes the mechanistic insights from studies explicitly examining the functional role of fat replacers in dough and baked goods (Section 'Mechanisms of Action'). While carbohydrate-based systems primarily act via water-binding and viscosity modification, structured lipids excel in mimicking fat's thermal and sensory behavior.

2.2 *Additives and shelf life*

Additives and fat replacers play a crucial role in extending the shelf life of bakery products by improving moisture retention, texture, and sensory quality. They can be classified into carbohydrate-based, protein-based, lipid-based, and hydrocolloid–emulsifier systems, each offering distinct functional benefits. The following sections categorize these additives, highlighting their substitution levels, effects on product quality, and impact on storage stability.

3. Carbohydrate-based fat replacers

Carbohydrate-based fat replacers, including fibers, polysaccharides, resistant starches, and vegetable purees, are widely used in bakery products to improve moisture retention, texture, and shelf life. Andrade et al. explored the use of galactomannan extracted from *Cassia grandis* seeds as a fat substitute in sponge cakes, testing concentrations up to 1%, with some formulations completely replacing vegetable fat. Physical evaluations showed that galactomannan helped maintain the cakes' specific volume, which is crucial for texture and quality. During storage, cakes with galactomannan retained moisture and exhibited reduced chewiness, indicating enhanced shelf life. However, sensory analyses revealed that some formulations were less acceptable to consumers, highlighting challenges in replicating the sensory qualities of traditional fat-based cakes. The study concluded that galactomannan holds promise as a fat replacer in sponge cakes, improving storage stability and maintaining physical properties, although further optimization is necessary to enhance sensory acceptability [21].

Ahsan et al. evaluated sago flour as a plant-based fat replacer in reduced-fat muffins, replacing butter at 25%, 37%, and 50% w/w. The study assessed physicochemical properties, sensory attributes, and nutritional enhancement during storage. Results showed that muffins with up to 37% butter replacement retained satisfactory textural and sensory features, including desirable firmness and density. Sago flour contributed to moisture retention, potentially extending shelf life and improving the nutritional profile by increasing mineral content. The study concluded that sago flour is an effective fat substitute in muffins, offering improved nutritional value, maintained quality, and positive effects on storage characteristics [22]. Mageed and Al-Abdullah aimed to develop a low-fat and low-calorie cake using margarine, oil, cake improver, Resistant Starch (RS), and Maltodextrin Glycerol (MDG). Substitution levels varied, and cakes were prepared by mixing flour, sugar, and fat substitutes, followed by baking at 170-175 °C for 40 minutes. Evaluations over 6 and 15 days of storage showed that fat replacement with margarine, oil, and MDG increased cake moisture content, helping maintain freshness. MDG prevented amylopectin retrogradation, reducing staling and maintaining cake firmness. Cakes with resistant starch and MDG retained favorable textural properties and achieved a shelf life comparable to traditional formulations. The study concluded that substituting fats with healthier alternatives, particularly MDG and RS, positively influenced cake shelf life and quality by enhancing moisture retention and reducing staling without compromising texture and taste [23]. Hussien studied the use of vegetable purees, specifically squash and cantaloupe, as fat substitutes in cake production at 25%, 50%, 75%, and 100% substitution. Cakes without any fat substitutes served as controls. Evaluations over 14 days showed that cakes with vegetable purees retained more moisture compared to controls, positively influencing sensory attributes and consumer acceptance. Moderate substitution levels (25% and 50%) maintained similar texture and sensory scores as controls, while higher substitution levels (75% and 100%) increased hardness and chewiness, with significant moisture loss over time. Cakes with 100% puree substitution were more susceptible to microbial contamination, limiting shelf life. The study concluded that vegetable purees are effective fat substitutes, improving moisture retention and sensory properties, but higher levels require careful formulation to avoid moisture loss and ensure stability [24]. Rizk et al. investigated water extracts from psyllium, mustard, and flax seeds as fat replacers in cakes, at 50% and 100% replacement levels. Cakes with fat replacers exhibited reduced bacterial and fungal counts over three weeks, with 100% mustard seed extract showing the lowest counts. Chemical analysis indicated maintained moisture, protein, fat, ash, crude fiber, total dietary fiber, and antioxidant activity. Sensory evaluations confirmed acceptable taste and texture at moderate substitution levels. The study concluded that psyllium, mustard, and flax seed extracts as fat replacers enhanced shelf life and microbial stability while providing potential nutritional benefits [25]. Caggia et al. evaluated Debittered Orange Fiber (DOF) from orange juice by-products as a fat replacer in brioches at 30%, 50%, and 70% replacement levels. Nutritional, technological, and microbiological analyses during storage indicated increased moisture content, higher dietary fiber and protein, and reduced fat. DOF contributed to improved shelf life, and sensory attributes were maintained. The study highlighted the potential of DOF as a functional ingredient improving nutritional profile, sensory quality, and stability of bakery products [26].

4. Protein-based fat replacers

Protein-based fat replacers, such as aquafaba and protein–hydrocolloid mixtures, provide emulsification, foam stabilization, and water-binding, supporting aeration and crumb structure. Grossi Bovi Karatay et al. studied Chickpea Aquafaba (CA)-based emulsions as substitutes for palm oil in pound cakes at 25%, 30%, and 35%. Analyses over 14 days showed slightly higher specific volume for CA cakes compared to palm oil, with moisture content and firmness changes suggesting improved texture retention. Sensory evaluations indicated no significant differences in aroma, texture, flavor, or overall impression, confirming CA as a feasible protein-based fat replacer maintaining cake quality [27]. Azmoon et al. used a hydrocolloid–protein mixture (konjac + guar gums + soy protein isolate, Mixture of Stabilizers (MOS)) in sugar-free, low-fat muffins, optimized via response surface methodology. Evaluations on days 1 and 15 showed that higher MOS percentages enhanced moisture retention, reduced hardness, maintained higher water activity, and improved textural stability. Sensory analyses indicated higher acceptability and cohesiveness for optimized MOS formulations, demonstrating the effectiveness of hydrocolloid–protein combinations in fat replacement [28]. Figure 2 presents the experimental workflow of Azmoon et al., demonstrating the use of Response Surface Methodology (RSM) to optimize hydrocolloid–protein mixtures in fat-reduced muffins [28].

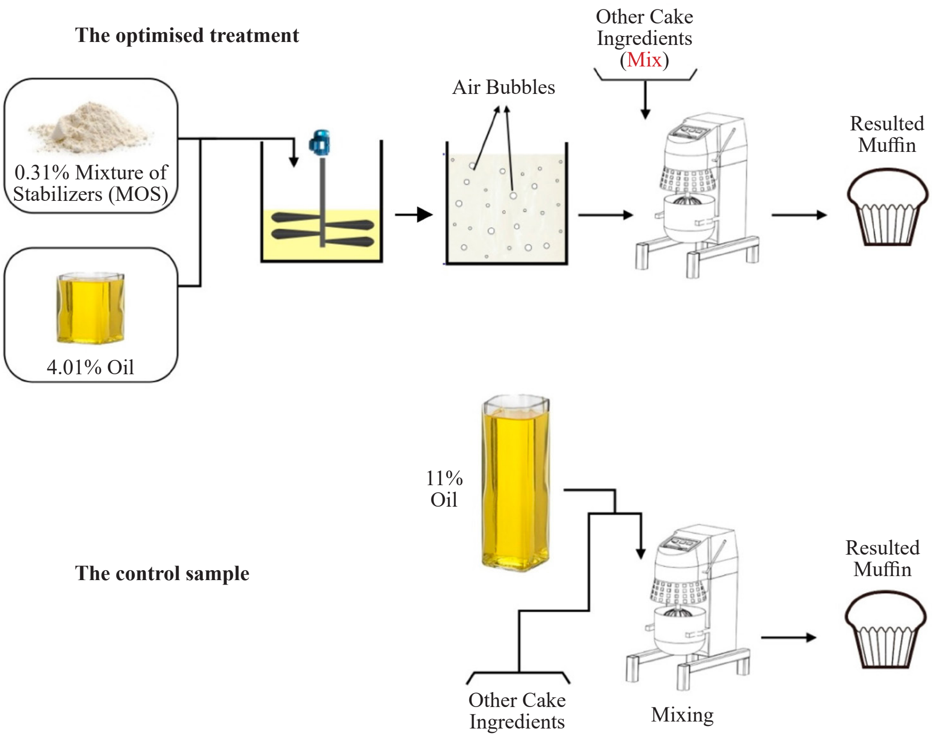

Figure 2. The treatment of protein-based fat replacers on crumb structure in comparison with the control [28]

5. Lipid-based systems and oleogels

Structured lipid-based fat replacers, including oleogels and Emulsion-Filled Gels (EFG), aim to replicate fat functionality while improving nutritional profile. Malvano et al. developed olive oil-based oleogels with beeswax, emulsifier E471, and whey proteins for plum cake, and evaluations over three months showed delayed staling, preserved hardness, water activity, porosity, and moistness. The unsaturated fatty acid composition contributed to extended shelf life and maintenance of texture, indicating strong potential as a healthier fat substitute in baked goods [29]. Banaś et al. tested agar–rapeseed oil hydroleogels as solid fat substitutes in shortbread cookies using cold-pressed, bleached, and refined canola oils. Baking loss, spreadability, texture, and crispiness were evaluated after baking and during 10 days of storage. Hydroleogels maintained low water activity, supporting stability, but cookies exhibited significantly reduced crispiness (70-180% lower) and higher baking losses compared to margarine. The study concluded that while hydroleogels contribute to shelf stability, optimization is needed to improve texture and overall quality [30]. Paciulli et al. investigated emulsion-filled gels (inulin + extra virgin olive oil) as butter replacers at 20%, 40%, and 50% in shortbread cookies. Cookies were stored for 60 days, and moisture content, water activity, texture, and color were monitored. EFG substitution increased moisture, caused an initial decrease in water activity followed by an increase, and maintained stability in dimensions, color, and sensory attributes. Darker coloration and enhanced sensory properties due to Maillard reactions were noted. The study concluded that EFG is effective, particularly at 40% substitution, supporting extended shelf life and sensory quality while reducing saturated fat [31].

Patel et al. reviewed fat mimetics, including ethylcellulose, protein–polysaccharide networks, and oleogels, across bakery, chocolate, and spreads. These materials replicated fat functionality, improved shelf life by reducing oxidative instability, enhanced storage stability, and provided potential health benefits, including cholesterol reduction, while maintaining desirable sensory attributes [32]. Zhang et al. examined plant-based fat substitutes using protein and polysaccharide complexes to mimic the texture and mouthfeel of traditional fats. Applications included soy oil bodies in mayonnaise, emulsion, and gel systems to encapsulate bioactive compounds, and alginate-based emulsion gels in meat products. The study showed that plant-based fat substitutes significantly contribute to shelf-life extension, maintaining texture, stability, and nutritional quality, while careful formulation is required to preserve organoleptic properties [33].

6. Hydrocolloids, emulsifiers, and mixed systems

Hydrocolloids and emulsifiers are often combined to improve texture, aeration, and storage stability. Fakhernia et al. tested chitosan, tragacanth, and HPMC with lecithin, glycerol monostearate, and Propylene Glycol Monoesters (PGME) in sponge cakes baked at 170 °C for 10 minutes and stored up to 12 weeks. Moisture content, texture, density, water activity, and color were monitored. Chitosan was most effective in retaining moisture; HPMC decreased true density, and lecithin reduced bulk density, producing a lighter texture. The study concluded that hydrocolloids and emulsifiers effectively improve shelf life and quality by enhancing moisture retention, reducing density, and supporting texture [34]. Moni et al. evaluated monoglyceride ester, glycerol monostearate, and disodium phosphate emulsifiers in cakes stored for 30 days. Emulsifiers reduced specific gravity, enhanced aeration, improved moisture retention, delayed staling, and preserved nutritional stability. Sensory evaluations showed improved texture and flavor, particularly with glycerol monostearate and disodium phosphate, although slight color degradation occurred after 30 days. Table 2 concluded that emulsifiers effectively extend shelf life while maintaining sensory and nutritional properties [35].

Table 2. Summary of studies on fat replacers in bakery products

Type of additive	Bakery product	Substitution level	Main findings on quality	Effect on shelf life	Ref.
Galactomannan (carbohydrate)	Sponge cake	Up to 1%, some formulations complete fat replacement	Maintained specific volume, reduced chewiness; some formulations less acceptable sensorially	Retained moisture, enhanced shelf life	[21]
Sago flour (carbohydrate)	Muffin	25%, 37%, 50% w/w butter replacement	Maintained desirable firmness and density; satisfactory sensory properties	Contributed to moisture retention; improved storage stability	[22]
Resistant Starch (RS) + MDG (carbohydrate)	Low-fat cake	Margarine & oil 25-100%, MDG 0.1-3%, RS 25%	Increased moisture, prevented staling, retained firmness and textural properties	Maintained freshness over 6-15 days	[23]
Vegetable purees (carbohydrate)	Cake	25%, 50%, 75%, 100% fat replacement	Moderate substitution-maintained texture and sensory quality; higher levels increased hardness	Moisture retention improved; higher substitution levels reduced shelf life due to spoilage risk	[24]
Psyllium/mustard/flax seed extracts (carbohydrate)	Cake	50%, 100% fat replacement	Maintained acceptable taste and texture at moderate levels	Reduced bacterial/fungal growth; extended shelf life	[25]
Debittered Orange Fiber (DOF) (carbohydrate)	Brioche	30%, 50%, 70% fat replacement	Increased moisture, improved texture and nutritional profile	Enhanced shelf life	[26]
Chickpea aquafaba (protein)	Pound cake	25%, 30%, 35% CA-based emulsions	Slightly higher specific volume; texture and sensory quality comparable to palm oil	Contributed to structure and texture retention	[27]
Hydrocolloid-protein mixture (konjac + guar + Soy Protein Isolate (SPI))	Muffin	Optimized via RSM	Improved moisture retention, reduced hardness, higher cohesiveness and acceptability	Maintained water activity; extended storage stability	[28]
Olive oil-based oleogel	Plum cake	Optimized mixture with beeswax, E471, whey proteins	Preserved hardness, porosity, moistness; maintained texture	Delayed staling; extended shelf life over 3 months	[29]
Agar-rapeseed oil hydroleogels	Shortbread cookies	Cold-pressed, bleached, refined oils	Maintained low water activity; reduced crispiness; higher baking loss	Supported shelf stability	[30]
Emulsion-filled gel (inulin + Extra Virgin Olive Oil (EVOO))	Shortbread cookies	Butter replacement 20%, 40%, 50%	Increased moisture content; maintained dimensions, color, and sensory properties	Supported shelf life; effective at 40% replacement	[31]
Fat mimetics (ethylcellulose, protein-polysaccharide networks, oleogels)	Bakery, chocolates, spreads	Various	Replicated fat functionality; maintained sensory attributes	Reduced oxidative instability; improved storage stability	[32]
Plant-based fat substitutes (protein/polysaccharide complexes)	Various food products	Various	Maintained texture and mouthfeel; encapsulated bioactive compounds; improved nutritional quality	Contributed to shelf-life extension; maintained stability	[33]
Hydrocolloids + emulsifiers (chitosan, tragacanth, HPMC + lecithin, Glycerol Monostearate (GMS), PGME)	Sponge cake	Various combinations	Improved moisture retention, reduced density, lighter texture	Enhanced shelf life and storage stability	[34]
Emulsifiers (monoglyceride ester, GMS, disodium phosphate)	Cake	Various	Reduced specific gravity; enhanced aeration, improved texture and flavor	Delayed staling; maintained nutritional stability	[35]

7. Challenges and limitations

As summarized in the book chapter "Baked Products", together with the works of Colla et al. and Gutiérrez-Luna et al., the challenges and limitations associated with the use of fat substitutes in bakery products were thoroughly examined. Fat plays a critical role in determining sensory attributes such as taste, texture, and aroma [9, 14, 36]. Replacing fat often results in higher hardness and less desirable sensory properties, particularly at higher substitution levels. Studies have indicated that partial fat replacement (less than 75%) is more likely to yield acceptable sensory results compared to complete substitution [9]. Consumer acceptance is another significant factor, as products failing to meet taste expectations may face rejection [36, 37]. Effective communication of health benefits and reformulation strategies is essential to enhance consumer acceptance [37]. On the technological front, Colla et al. noted that the structural properties of fat replacers vary significantly, impacting the overall quality of baked products [36]. Techniques like oleogelation have shown promise, but the complexity of formulation and processing can pose practical challenges [9]. Despite these obstacles, oleogels face challenges in widespread industrial application due to higher production costs and efficiency concerns, even though ongoing research seeks more economical alternatives. [38-40]. Simultaneously, EU Regulation 2015/2283 on novel food ingredients poses a regulatory hurdle for new bakery components, necessitating rigorous safety assessments for substances not significantly consumed before 1997, including various insect-derived ingredients [41-43].

In addition, a significant challenge in the development of reduced-fat bakery products is the consumer perception bias that these items are inherently less tasty, regardless of their actual sensory profile. Efforts to decrease fat content in baked confectionery products often aim to do so without compromising sensory quality, which includes attributes like structure, texture, aroma, and taste [44]. However, the removal of fat can impair the sensory and textural properties of foods, potentially leading to lower consumer acceptance [45]. This necessitates considerable research into modifying product formulations and utilizing fat substitutes to maintain desirable sensory characteristics and overcome this negative perception [46]. Research into innovative fat substitutes and reformulation strategies continues to seek improvements in the nutritional profile of bakery products while maintaining sensory quality. However, balancing health benefits with consumer satisfaction remains a critical hurdle for the industry.

8. Future directions

Despite significant progress, several research gaps warrant attention:

(1) Hybrid systems: Combining oleogels with protein–hydrocolloid networks to achieve full fat replacement without sensory loss.

(2) Clean-label oleogelators: Natural waxes (e.g., rice bran, sunflower) to replace synthetic HPMC.

(3) Standardized sensory protocols: Use of trained panels and electronic nose/tongue for cross-study comparison.

(4) Life Cycle Assessment (LCA): Evaluating the environmental impact of fat replacers vs. traditional fats.

(5) Industrial scale-up: Pilot studies on extrusion and high-speed mixing compatibility.

9. Conclusion

The use of fat substitutes in bakery products offers significant potential for creating healthier alternatives to traditional baked goods while maintaining their desirable sensory characteristics. Oleogels, carbohydrate-based substitutes such as inulin, and protein-based alternatives like whey protein and amaranth flour each play an important role in reducing fat content and enhancing the nutritional profile of bakery items. These substitutes can improve texture, moisture retention, and even antioxidant activity, all of which contribute to a more health-conscious product. However, despite their benefits, complete fat replacement often leads to undesirable changes, such as increased hardness, reduced volume, or compromised sensory appeal. While partial fat replacement (up to 75%) tends to yield more favorable results in terms of texture and flavor, there are still challenges in maintaining the sensory qualities that consumers expect from traditional full-fat products. The incorporation of emulsifiers and fat mimetics, such as oleogels, has proven to be effective in improving product stability, extending shelf life, and enhancing storage properties by reducing oxidative instability. These systems help retain moisture and prevent staling, while also preserving texture and flavor during extended storage. Despite the positive outcomes of using these substitutes, the complexity of their formulation and processing remains a challenge, as the structural properties of the fat replacers can significantly impact the overall quality of the baked goods. Consumer acceptance is another crucial factor to consider, as the sensory qualities of the final product, including taste, texture, and aroma, are pivotal to its success. Products that do not meet taste expectations may face rejection, regardless of their health benefits. As a result, continuous research into innovative fat substitutes and formulation strategies is essential to overcome these challenges. The goal is to develop bakery products that are both nutritionally enhanced and sensory-appealing, striking a balance between health benefits and consumer satisfaction. Further research into optimizing fat replacers and improving processing techniques will be key to advancing the production of healthier, high-quality bakery products.

Conflicts of interest

The authors declare that they have no relevant conflicts of interest.

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