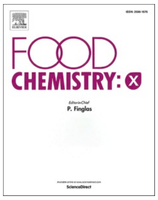
Food Chemistry: X 21 (2024) 101215

Contents lists available at ScienceDirect

Food Chemistry: X

journal homepage: www.sciencedirect.com/journal/food-chemistry-x



Effects of hydrocolloids and oleogel on techno-functional properties of dairy foods

Shan Zhang [a], Chuanying Ren [a,b], Caiyun Wang [c], Renjiao Han [d], Siyu Xie [c,*]

[a] *Food Processing Research Institute, Heilongjiang Academy of Agricultural Sciences, Harbin 150086, China*
[b] *Heilongjiang Province Key Laboratory of Food Processing, Harbin 150086, China*
[c] *Inner Mongolia YiLi Industrial Group Co., Ltd., Hohhot 010110, China*
[d] *Inner Mongolia National Center of Technology Innovation for Dairy, Hohhot 010110, China*

ARTICLE INFO

Keywords:
Hydrocolloids
Oleogel
Dairy foods
Techno-functional properties

ABSTRACT

This paper aims to overview the influence of different gels that including hydrocolloids and oleogel on techno-functional changes of dairy foods. The hydrocolloids are widely added to dairy products as stabilizers, emulsifiers, and gelling agents to enhance their texture, or improve sensory properties to meet consumer needs; and the newly developed oleogel, which despite less discussed in dairy foods, this article lists its application in different dairy products. The properties of different hydrocolloids were explained in detail, meanwhile, some common hydrocolloids such as pectin, sodium alginate, carrageenan along with the interaction between gel and proteins on techno-functional properties of dairy products were mainly discussed. What's more, the composition of oleogel and its influence on dairy foods were briefly summarized. The key issues have been revealed that the use of both hydrocolloids and oleogel has great potential to be the future trend to improve the quality of dairy foods effectively.

1. Introduction

Dairy products are rich in protein and fatty acids, which are important components of a balanced and nutritious diet in people's life. The quality control of dairy products is an important link in the food regulatory system (Bondoc and Sindilar, 2002). However, various quality problems are always encountered because of the production system, hygienic, and storage condition and so on (Bondoc, 2007). However, various problems are always encountered during the processing process (Gilbert et al., 2020). Gel plays an important role in forming the quality of dairy products because of its special organizational structure, for example, hydrocolloids have effects in thickening, texturing and stability, and oleogel has considerable advantages in quality improvement, nutrition enhance and fat replacement (Cui et al., 2023; Rafiq et al., 2020). Nowadays, hydrocolloids and oleogel have an inestimable development prospect in dairy products with the improvement of people's requirements for health (Arioui et al., 2017; Manzoor et al., 2022).

Hydrocolloids have long been the focus of scientific interest as thickeners, stabilizers, and other additives due to their ability to form colloidal solutions through strong interactions with water. Globally, consumers' demand for desirable textural, sensory and nutritional benefits of dairy products have driven the increase of hydrocolloids market share. The global hydrocolloids market is estimated to be valued at USD 11.2 billion in 2023 and is projected to reach USD 14.5 billion by 2028 (https://www.marketsandmarkets.com/PressReleases/hydrocolloid.asp), The increasing demand for hydrocolloids is mainly for its ability to provide a stable lotion system for dairy products and prevent whey precipitation and protein aggregation during the shelf life (Javidi et al., 2016). By forming several types of bonds, including covalent, electrostatic interaction, excluded volume, hydrophobic interactions, van der Waals forces, hydrocolloids form a gel network system with milk proteins to improve the texture of the dairy (De Kruif and Tuinier, 2001; Wusigale et al., 2020).

Oleogel, also referred to as organogels, has been developing in recent years, and because its non-edible components, it is rarely used in food, and the research on improvement and application of dairy products is even less. According to relevant data, oleogel has certain research value in the application of biomaterials such as condiments (salad sauce, chocolate sauce), 3D printing, and nutrient delivery because of its unique structure and fat content. However, with the continuous pursuit of healthy fat in food, oleogel is a thermoreversible viscoelastic

---

* Corresponding author.
E-mail address: xiesiyu2406@163.com (S. Xie).

https://doi.org/10.1016/j.fochx.2024.101215
Received 6 November 2023; Received in revised form 7 February 2024; Accepted 7 February 2024
Available online 10 February 2024
2590-1575/© 2024 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

semisolid systems that can contain more than 90 % of healthy oils, its fat replacement ability in food cannot be ignored. Oleogel forms a three-dimensional gel network that traps healthy fats with high unsaturated fats acid content whereby π-π stacking, hydrogen bonding, electrostatic and van der Walls interactions (Huang et al., 2018; Okesola et al., 2015; Okuro et al., 2020). This structure can increase the quality level, and replace saturated fats in the dairy product, what's more, it increases the content of fatty acids and improves the nutritional structure.

Yogurt, cheese and ice cream are semi-solid foods. Whipped cream belongs to oil in water emulsion. No matter what kind of dairy food, they need to maintain a certain degree of shelf-life stability (Yousefi and Jafari, 2019). Different products have different shelf-life stability indicators: whey separation of yogurt, oil separation of cheese, melting resistance of ice cream and coagulation, precipitation, oil–water separation of whipped cream. Hydrocolloids can help dairy products improve the above indicators by connecting with milk proteins (Biglarian, et al., 2021; Pang, et al., 2017; Samakradhamrongthai, et al., 2021) Carrageenan, xanthan and guar gum are widely used to increase the stability of the dairy product (Černíková et al., 2010; Hussain, et al., 2017; Jagdish, et al., 2014). The improvement of nutritional quality is imperative besides sensory quality, such as the replacement of solid fat and trans fatty acid in four dairy products. The oleogel can use its unique three-dimensional network structure to improve the nutritional quality and reduce the content of hydrogenated oil and saturated oil in dairy products.

Many reviews have been published on the application of hydrocolloids in dairy products (Mezzenga et al., 2005; Moriano and Alamprese, 2017; Yousefi and Jafari, 2019). However, there is no complete and comprehensive review of hydrocolloids and oleogel application in dairy foods that covers yogurt, cheese, ice cream and whipped cream. In this review, the functions of hydrocolloids and the effects of the hydrocolloids on yogurt, cheese, ice cream and whipped cream are introduced. The mechanism of hydrocolloids and milk proteins is discussed and compared. Meanwhile, the composition of oil gel and its application in yogurt, cheese, ice cream and raw cream were illustrated. Last, different chemical structures of hydrocolloids determining the texture of dairy foods are also discussed. This work provides comprehensive knowledge covering all aspects for using hydrocolloids and oleogel in the dairy products.

2. Types and characteristics of hydrocolloids in dairy products

Hydrocolloids are divided into polysaccharide-based and protein-based. Protein-based hydrocolloids mainly include gelatin. Polysaccharide-based is mainly divided into anionic, cationic and non-ionic polysaccharides. Anionic polysaccharides mainly include cellulose, gum arabic, gum tragacanth, carrageenan, pectin and xan than, cationic polysaccharides including guar gum, non-ionic polysaccharides including starch and inulin (Figure S1).

2.1. Hydrocolloids in yogurt

The consumption of yogurt dominates the market largely, for its not only nutrients but also unique texture characteristics and sensory properties (Lal et al., 2006). During the whole yogurt production, the pH of milk decreases from 6.7 to 4.3. In this process, casein micelles demineralize, the net charge content of micelles decreases, the electrostatic interaction between micelles decreases, and finally, the repolymerized casein forms a 3D casein-casein network structure, which forms the basic gel network of yogurt. But after adding various hydrocolloids, it changes to different textures and sensory properties of yogurt.

Modified starch is used to reduce the syneresis of yogurts by changing yogurts' microstructure. Compared with native starch, phosphorylated starch significantly lowered the syneresis in yogurts. The phosphate groups in the starch molecules will be the affinities to whey of the yogurt. Research showed that the modified starch can be adsorbed on the surface of casein in yogurt, leading to the casein un-flocculation, and the interaction between this hydrocolloid and casein can form a three-dimensional gel network which to maintain the aqueous phase, thereby increasing the viscosity and decreasing the syneresis of yogurt (Cui, Tan, Lu, Liu, & Li, 2014; Pang et al., 2019). What's more, many researchers add hydrocolloids, such as gelation, pectin or modified starch into yogurt to control syneresis. Among these polysaccharides, pectin and modified starch have been more conspicuous.

Viscosity and rheological properties are other important parameters in the textural quality of yogurt. Incrementing the pectin concentration from 0.0 to 0.5 % *w/w* demonstrated a decrease at apparent viscosity (Ramaswamy and Basak, 1992) showed that the addition of pectin up to 0.6 % *w/w* strengthened the casein network via bridging of casein aggregates by the electrostatic interaction (Arioui et al., 2017). Table 1 shows some examples demonstrating the application of hydrocolloids in yogurt.

2.2. Hydrocolloids in cheese

Hydrocolloids are becoming a broader additive for different types of cheese. The use of hydrocolloids can improve the textural properties such as enhancing the hardness, controlling the meltability and reducing the syneresis. One of the peculiar features of hydrocolloids that has made them suited in cheese production is their ability for fat replacement by producing a texture similar to full-fat cheese. Various studies have been performed regarding the use of hydrocolloids to replace fat in low-fat cheese. Examples comprise the utilization of guar gum, xanthan gum, carrageenan and gum tragacanth. For example, two studies focused on the effects of xanthan gum and carrageenan as fat replacers in low-fat cheese, one study indicated that supplementation of cheese with xanthan gum reduced the hardness factor (Nateghi et al., 2012). But another study showed the opposite result, carrageenan will increase the hardness of cheese (Černíková et al., 2010).

The texture that hydrocolloids produce, including cohesiveness, chewiness, springiness, and hardness are extensively investigated. The addition of hydrocolloids to cheese is a main method for affecting these parameters. For example, (Kurt et al., 2016) showed that adding 0.23 % sodium alginate to low-fat cheese decreased the chewiness, hardness, cohesiveness, and gumminess (Khanal et al., 2018). However, hydrocolloids could also bring some adverse impacts on sensory properties of cheese. Incorporation of κ-carrageenan and ι-carrageenan into the processed cheese spread at different levels of 0.1–0.4 % (w/w) and 0.1–0.3 % led to the cheese very hard (Černíková et al., 2010). The similar result was obtained by Lashkari, H. et al. (2014). They found out that the addition of 1.4 % gum arabic to low-fat Iranian white cheese samples resulted in an undesirable hard texture (Lashkari et al., 2014). In addition to the above applications, a number of effects of hydrocolloids on the texture properties of cheese have been summarized in Table 2.

2.3. Hydrocolloids in ice cream

Hydrocolloids are widely added to ice cream. Researchers add hydrocolloids to the ice cream to increase its viscosity, which keeps this emulsion system at a low temperature without oil–water separation, grease accumulation, milk solids precipitation and recrystallization growth. Recent published researches show that locust bean gum and guar gum are becoming popular in making ice cream.

Melting rate is one of the main parameters related to ice cream shape preservation. Except depending on the heat transfer phenomena, the meltdown of ice cream can be affected by hydrocolloids. It has been found that there is a negative direct relationship between hydrocolloids concentration and ice cream melting rate (Cropper et al., 2013). Considering the consumers' acceptability, hydrocolloids addition in the ice cream is limited. Since more added hydrocolloids cause an increment in serum viscosity, heat energy will take a longer time to transfer from

Table 1
The influence of some hydrocolloids on properties of yogurt at different conditions.

Hydrocolloid	Yogurt type	Conditions	Results	References
Alginate	Set yogurt	Concentrations of hydrocolloids (0.6 % *w/w*)	Addition of 0.6 % alginate made a negative contribution to camel milk yogurt's syneresis and water holding capacity.	(Al-Zoreky and Al-Otaibi, 2015)
Carrageenan	Frozen yogurt	κ-carrageenan (0.05—0.15 *w/w* %)	The addition of 0.15 *w/w* % κ-carrageenan offered the frozen yogurt the highest hardness and stickiness and positively affected on sensory attributes.	(Skryplonek et al., 2019)
Cellulose	Bio-yogurt	Cellulose fiber (0.5–2 % *w/w*)	There was a positive direct relationship between the serum separation, water holding capacity, and texture properties with cellulose fiber amount.	(Güler-Akın et al., 2018)
Curdlan	Functional-yogurt	Curdlan (10 % *w/w*)	Yogurt fortified with curdlan showed a significant increase in water holding capacity.	(Martinez et al., 2016)
Gelatin	Camel milk yogurt	Gelatin (0–1.25 % *w/w*)	Production of yogurt with gelatin reduced syneresis, especially at 1–1.25 wt% level.	(Mudgil et al., 2018)
	Low-fat stirred yogurt	Gelatin (0–0.4 % *w/w*)	There was a direct relationship between whey separation and gelatin addition amount in yogurt, 0.4 wt% gelatin completely preventing syneresis.	(Pang et al., 2017)
Gellan gum	Traditional Iranian yogurt-based drink	Gellan gum (0.01–0.05 % *w/w*) with pectin (0–0.25 % *w/w*)	Gellan gum (0.05 % *w/w*) combined with 0.25 % *w/w* pectin resulted in serum volume reduction and organoleptic acceptability augment.	(Kiani et al., 2010)
Guar gum	Set yogurt	Guar gum (0.3–1.0 % *w/w*)	Guar gum led to yogurt with better desirable features, fine-stranded microstructure and better rheology properties.	(Hussain et al., 2017)
Gum arabic	Camel milk yogurt	Gum arabic (0–0.2 % *w/w*)	Addition of gum arabic negatively affected on hardness, viscosity, and rheology of yogurt fortified with casein.	(Sobti et al., 2020)
Gum tragacanth	Kashk yogurt	Gum tragacanth (0.1–0.3 % *w/w*)	Gum tragacanth (0.5 *w/w* %) could reduce the syneresis and increased viscosity.	(Shiroodi et al., 2012)
	Non-fat yogurt	Gum tragacanth (0.025–0.1 % *w/w*)	Gum tragacanth as fat replacers had a negative effect on the physical properties and sensory attributes.	(Aziznia et al., 2009)
	Camel milk yogurt	Gum tragacanth (0.025–0.1 % *w/w*)	The addition of gum tragacanth causes yogurt structure coarser and more open, leading greater tendency for syneresis.	(Aziznia et al., 2008)
Inulin	Soy milk yogurt	Inulin content (20 g/L-70 g/L)	With the increment of inulin content, creaminess and viscosity increase were observed. Furthermore, 50 g/L was considered as the best additive amount from smell, colour, and flavor.	(Rinaldoni et al., 2012)
Locust bean gum	Set yogurt	Locust bean gum (0–0.5 % *w/w*)	The yogurt prepared with 0.5 *w/w* % locust bean gum showed syneresis decrease, viscosity increase.	(Pancar et al., 2016)
Pectin	Yogurt	Pectin (0–0.6 % *w/w*)	The best viscosity was observed in yogurt added with 0.6 % pectin. With pectin concentration increasing, the acidity and viscosity increased.	(Arioui et al., 2017)
	Greek-style yogurt	Pectin (0.5 % *w/w*)	Pectin (0.5 % *w/w*) with whey protein (1.0 % *w/w*) has positive implications for controlling syneresis in Greek-style yogurt.	(Gyawali and Ibrahim, 2018)
	Stirred commercial yogurt	Pectin (0.0–0.5 % *w/w*)	Pectin resulted in increased viscosity in stirred yogurt.	(Ramaswamy and Basak, 1992)
	Stirred skim-milk yogurt	Pectin (0.5–5.0 g/L)	Increasing levels of low-methoxy pectin resulted in higher apparent viscosity and water holding capacity.	(Everett and McLeod, 2005)
Starch	Set yogurt	High-amylose corn starch (1.5 % *w/w*) or physically modified corn starch (1.5 % *w/w*)	Physically modified corn starch can improve the qualities of yogurt containing titratable acid decrease, the viscosity and system stability increase.	(He et al., 2019)
	Yogurt	Cross-linked acetylated starch different acetyl cross linking degree (4.6–89.5) (ADP-L (0.9–1.2 *w/w*), ADP-M (1.5–2.0 *w/w*) and ADP-H (1.6–2.0 *w/w*)	Acetylated distarch phosphate showed increasing positive effect on apparent viscosity, firmness, adhesiveness of yogurt.	(Pang et al., 2019)
		Phosphorylated starches (0.82–4.18 *w/w*)	The more numerous the phosphate groups in the phosphorylated starch, the better the retention capacity and texture stability of the yogurt with the starch will be.	(Martín-Martínez et al., 2004)
		Physically modified starches (2.0 *w/w*)	Addition of physically modified starch in yogurt could improve the consistency and impart creaminess.	(Morell et al., 2015)
	Reduced-fat yogurt	Modified tapioca starches (g/L)	Yogurt with modified tapioca starch as fat replacer showed higher firmness than full-fat starch.	(Sandoval-Castilla et al., 2004)
		Chemically modified maize starches (1.5–2.0 *w/w*) or tapioca starches (1.5–2.0 *w/w*).	The addition of chemically modified starches to reduced-fat yogurts contributed to a more stable acidified milk gelled network.	(Lobato-Calleros et al., 2014)
		Enzymatically modified potato starches (0.05–1.0 *w/w*)	The yogurt of syneresis, water holding capacity and viscosity were meaningfully lower in samples containing modified starch.	(Nikitina et al., 2019)
Xanthan gum	Set yogurt	Xanthan gum (0.1–1.0 % *w/w*) and guar gum (0.1–1.0 % *w/w*)	Xanthan gum (0.5 *w/w* %) was best for preventing syneresis, improving water holding capacity and viscosity, and augmenting texture property.	(Rafiq et al., 2020)
	Frozen yogurt	Xanthan (0–0.2 % *w/w* %)	Xanthan (0.2 % *w/w* %) were utilized synergistically to increase frozen yogurt creaminess and increase overall acceptance.	(Soukoulis & Tzia, 2008)

Table 2
The influence of some hydrocolloids on properties of cheese at different conditions.

Hydrocolloid	Cheese type	Conditions	Results	References
Carboxymethyl cellulose (CMC)	Mozzarella cheese	CMC (0 – 0.5 w/w %)	By the hydrophobic interaction, CMC could be used as texturizer and crosslinking agents in mozzarella cheese.	(Li et al., 2019)
Carrageenan	Processed cheese	κ-carrageenan (0.1–0.4 *w/w* %) and ι-carrageenan (0.1–0.3 *w/w* %)	The final product was very hard.	(Černíková et al., 2010)
	Low-fat Colby cheese	κ-carrageenan (0.3 *w/w* %) and ι-carrageenan (0.3 *w/w* %)	Carrageenan can improve the texture and rheological properties as fat replacers.	(Wang et al., 2016)
	Processed cheese	κ-carrageenan (0–0.25 *w/w* %)	The addition of κ-carrageenan showed a significant increase in G* and hardness.	(Hanáková et al., 2013)
Gelatin	Petit suisse cheese	Gelatin (0–3 %)	There was a difference between cheese with gelatin and control, not only in sensory acceptance but also in texture analysis.	(Bermudez-Beltrán et al., 2020)
Gum arabic	Low-fat Iranian white cheese	Gum arabic (0.4—1.4 *w/w* %)	Gum arabic at concentrations at 0.4–1.4 *w/w* % give rise to an undesirable hard texture.	(Lashkari et al., 2014)
Gum tragacanth	Half-fat cheddar cheese	Gum tragacanth (0–0.05 % *w/w* %)	The addition of gum tragacanth as fat placer cannot mimic the full-fat cheese sensory properties fully.	(Cooke et al., 2012)
	Low-fat cheese	Gum tragacanth (0–1.0 g/Kg)	The more compact microstructure led to texture and sensory properties improving.	(Rahimi et al., 2007)
Pectin	Processed cheese	Pectin (0.2–0.8 *w/w* %)	The cheese added pectin was more rigid and less spreadable than cheeses without pectin.	(Macků et al., 2008)
	Kariesh cheese	Pectin (0–0.4 *w/w* %) and CMC (0–0.6 % *w/w*)	*Kariesh cheese* made with 0.4 *w/w* % pectin and 0.6 % *w/w* CMC recorded the highest scores from the perspective of having lower hardness, springiness, adhesiveness, chewiness, and gumminess.	(Korish and Abd Elhamid, 2012)
Starch	Low-fat cheese	Acetylated maize starch (0.5–0.15 *w/w* %) and hydroxypropylated maize starch (0.5–0.15 *w/w* %)	Acetylated maize starch (0.5–0.15 *w/w* %) and hydroxypropylated maize starch (0.5–0.15 *w/w* %)	(Diamantino et al., 2019)
Sodium alginate	Low-fat cheese	Sodium alginate (0.12 – 0.23 w/w %)	The addition of sodium alginate as a fat placer improved the body texture significantly and resulted in the formation of porous microstructure entrapping more water.	(Khanal et al., 2018)
Xanthan gum	Low-fat cheddar	Xanthan gum (0–0.045 *w/w* %) and sodium caseinate (0–0.045 *w/w* %)	Applying xanthan gum and sodium caseinate in cheese is a considerable choice. Xanthan gum (0.045 *w/w* %) or low sodium caseinate can decrease the hardness and gumminess.	(Nateghi et al., 2012)
	Cream cheese	Xanthan gum (0.3 *w/w* %)	Compared with combined stabilizer (xanthan gum, locust bean gum, and guar gum), using xanthan gum can produce sticker and softer cream cheese for spreading easily.	(Brighenti et al., 2020)
	Mozzarella cheese	Xanthan- locust bean gum (1:1, 0.42 *w/w* %)	Xanthan- locust bean gum would be the best choice as a mixed stabilizer to improve sensory and stability in cheese compared with xanthan-carrageenan.	(Jana et al., 2010)
β-glucan	Low-fat cheddar cheese	β-glucan	Significant fat replacement with the β-glucan resulted in softer Cheddar cheeses with decreased melt times and sensory scores.	(Konuklar et al., 2004)
	Low-fat mozzarella cheese	β-glucan (0.06 00.12 *w/w* %)	Low fat cheese control (5 % fat) with β-glucan showed the softer texture and the greatest melt and stretch properties.	(Vithanage et al., 2008)

the exterior layers of ice cream to interior layers. Therefore, hydrocolloids can decrease the melting rate of ice cream (Seo and Oh, 2022).

As the ice cream colloidal system contains a number of ice crystals, uncontrolled growth of ice crystals is one of the primary difficulties for ice cream consumption. By adsorbing onto the surface of crystals, modifying the rate of water molecules adsorption onto or go away from crystals, hydrocolloids can influence the interface properties between serum and ice crystals throughout freezing and storage. Furthermore, forming a three-dimensional gelation network between hydrocolloids and milk protein through hydrogen bonds creates an obstacle to the growth of large ice crystals. The firmness of gel could repress recrystallization. In many studies, ice crystal growth in frozen ice cream was meaningfully retarded in samples containing locust bean gum, xanthan and inulin. More examples applicating hydrocolloids in ice cream are shown in Table 3.

2.4. Hydrocolloids in whipped cream

Addition of hydrocolloids is considered as a practical method for preparation, production, and preservation of whipped cream. Whipped cream refers to the fat-containing part (30.0 % to 40.0 %) separated from milk as raw material, with or without other raw materials and food additives, and is processed into a product used in the food sector. Due to the unique application characteristics of whipped cream, it is becoming more and more popular in the food market. However, there are several conflicts in whipped cream production. Whipped cream is a thermodynamically unstable emulsion system. According to the law of thermodynamics and the principle of minimum energy, when there are no other factors, the emulsion will quickly undergo phase separation to reduce the interface contact area and reduce the system's free energy. Whipped cream should be stable against aggregation during storage and properly partially coalesced during the whipping process. Hence several hydrocolloids are often used to balance these conflicts in whipped cream products.

Polysaccharides are very effective in improving the stability of emulsions (Murayama et al., 2021). Appropriate polysaccharides can enhance the viscosity of emulsions, thereby delaying the rate of fat aggregation during storage. Besides, an irreversible covalent complex is formed between the hydrocolloids and milk protein (Klein et al., 2010). Compared with a single protein or a single polysaccharide, this covalent complex has better solubility and emulsification properties, and adsorption on the fat droplet interface can improve the stability of the emulsion. This can also enhance its functional properties, such as whipping properties. A brief overview of the applied hydrocolloids in whipped cream are given at Table 4.

3. Types and characteristics of oleogel in dairy products

Solid fat plays an irreplaceable role in dairy foods. It is responsible for imparting unique flavor, mouthfeel and texture for dairy products, satisfying the processing requirements of dairy products for plasticity and strong stability (Patel et al., 2020). For example, solid fat can

Table 3
The influence of some hydrocolloids on properties of ice cream at different conditions.

Hydrocolloid	Ice cream type	Conditions	Results	References
Basil seed gum	Low fat ice cream	Basil seed gum (0.35–0.55 *w/w* %)	Addition of basil seed gum had ability to reduce the meltdown rate and extent of melting of ice cream.	(Javidi et al., 2016)
Carboxymethyl cellulose	Goat milk ice cream	Carboxymethyl cellulose (0.2 *w/w* %) and gelatin (0.2 *w/w* %)	Carboxymethyl cellulose improved the texture of the ice cream.	(Ma et al., 2014)
Cellulose	Low fat ice cream	Cellulose nanofibrils (0.15–0.3 *w/w* %)	In 10 wt% fat ice cream, cellulose nanofibrils (0.3 wt%) not only increased mix rheology and shape retention but prolonged fat destabilization and onset time.	(Velásquez-Cock et al., 2019)
	Soft ice cream	Cellulose nanofibrils (0.3–0.5 *w/w* %)	Carboxymethylcellulose made a significant effect to physicochemical and sensory characteristics of ice cream.	(Bahramparvar et al., 2009)
Carrageenan	Ice cream	κ-carrageenan	Ice cream got the better stabilization and high melting resistance with κ-carrageenan/milk protein isolate mixture.	(Seo and Oh, 2022)
		κ-carrageenan (0–0.02 *w/w* %), basil seed gum (96.94 % *w/w* %) and guar gum (3.06 *w/w* %)	Addition of κ-carrageenan had no significant impact on melting rate of ice cream, but increased the hardness of ice cream significantly.	(BahramParvar et al., 2013)
Guar gum	Normal ice cream	Guar gum (0.1–0.4 *w/w* %)	Guar gum was used in ice cream to stabilize it, and incorporating with 0.4 *w/w* % guar gum resulted in the highest viscosity.	(Jagdish et al., 2014)
Gum tragacanth	Salep based ice cream	Gum tragacanth (0–0.5 *w/w* %)	Ice cream with gum tragacanth showed an increased in elastic and viscous behaviors.	(Kurt et al., 2016)
Inulin	Yogurt-ice cream	Inulin (5.0–9.0 *w/w* %)	A positive relationship between the content of inulin increasing and the melting property improving was observed.	(El-Nagar et al., 2002)
	Low-fat ice cream	Inulin (4.0 *w/w* %)	Addition 4 *w/w* % inulin increased the hardness of ice cream and increased the melting speed.	(Akalın et al., 2007)
	Reduced-fat ice cream	Inulin (2.0–5.0 *w/w* %)	The addition of inulin increased the firmness of reduced-fat ice cream significantly. In the presence of 8.58 % sugar and 22.18 % whipped cream, 4.02 % inulin gave the ice cream appropriate firmness, viscosity and melting rate.	(Samakradhamrongthai et al., 2021)
Locust bean gum	Kahramanmara-type ice cream	Locust bean gum (0.3–0.4 *w/w* %) combined with CMC	The use of locust bean gum combined with CMC, guar gum, or alginate provided the better properties (overrun values, penetrometer values, and viscosity) for the ice cream.	(Guven et al., 2003)
	Non-fat ice cream	Locust bean gum (0.25 *w/w* %)	Locust bean gum can lead to more week network, especially in milk solids not-fat in the ice cream.	(Patmore et al., 2003)
	Low-fat ice cream	Locust bean gum (0–0.23 *w/w* %)	At constant mono and diglyceride levels, locust bean gum decreased the melting rate of ice cream significantly.	(Cropper et al., 2013)
Pectin	Reduced-fat ice cream	Pectin (0–0.15 *w/w* %)	Ice cream with 0.72 % pectin got lower mouth-coating scores and higher smoothness scores.	(Zhang et al., 2018)
Xanthan gum	Normal ice cream	Xanthan gum (0.0–0.8 *w/w* %)	Xanthan gum was added to ice cream, and with xanthan gum concentration increasing, steady and dynamic rheology of ice cream increased.	(Dogan et al., 2012)

Table 4
The influence of some hydrocolloids on properties of whipped cream at different conditions.

Hydrocolloid	Whipped cream type	Conditions	Results	References
Carboxymethylcellulose	Whipped cream	Carboxymethylcellulose (0.03 % wt/wt)	Formulation containing 0.03 % κ-carrageenan and 0.01 % cremodan se 80 can decrease whipping time and increase overrun.	(Gafour and Aly, 2020)
Carrageenan	Natural whipped cream	κ-carrageenan (0.0 %-0.04 % wt/wt)	A positive correlation of κ-carrageenan addition on whipping cream functional properties (whipping time and whipped foam) was observed.	(Kováčová et al., 2010)
		κ-carrageenan (0.0 %-0.04 % wt/wt) and basil seed gum	A better synergistic interaction effect of κ-carrageenan and basil seed gum on desirable physical structure for whipped cream was observed.	(Biglarian et al., 2021)
		l-carrageenan (0.0 %-0.1 % wt/wt)	Strong interaction of l-carrageenan with caseins made great contribution to viscosity increase of whipped cream.	(Camacho et al., 2005)
		l-carrageenan (0.0 %-0.1 % wt/wt)	Whipped cream containing 0.085 % l-carrageenan showed a well firmness during freezing-thawing process.	(Camacho et al., 2001)
	Low-fat whipped cream	κ-carrageenan (2.5 %-15.0 % wt/wt)	Stabilizer blends adding high level of κ-carrageenan could decrease in overrun, while increasing the whipped cream' viscosity.	(Ghribi et al., 2021)
Cellulose fiber	Low-fat whipped cream	Modified cellulose fiber (0.5 %-1.5 % wt/wt)	Modified cellulose fiber with improved textural properties could be used in low-fat whipped cream.	(Athari et al., 2021)
Hydroxypropyl methylcellulose	Natural whipped cream	Hydroxypropyl methylcellulose (0.025–0.125 % wt/wt)	Hydroxypropyl methylcellulose showed a positive dose-dependent effect on firmness, cohesiveness, consistency and viscosity of whipped cream.	(Zhao, Zhao, Li, et al., 2009)
	20 %-fat whipped cream	Locust bean gum (0.0–0.15 % wt/wt)	Increasing locust bean gum concentration led to higher values of apparent viscosity, firmness, and average particle size and lower values of overrun and foam stability.	(Rezvani et al., 2020)
Xanthan gum	Natural whipped cream	Xanthan gum (0.025–0.125 % wt/wt)	A positive influence was found between xanthan gum content and cohesiveness, firmness or viscosity of whipped cream.	(Zhao, Zhao, Yang, et al., 2009)

improve the melting resistance and stabilize the complex system of ice cream, and provide aroma for cheese products as well. However, with the rapid increase of incidence rate and Case fatality rate of cardiovascular diseases, people gradually attach importance to reducing the consumption of solid fat in daily diet. This is mainly because it has been found that the gut is regarded as an essential digestive organ in the human body and is closely associated with diet-related pathologies such as cardiovascular diseases, diabetes, and obesity. A high-fat diet can lead to a decrease in the abundance of beneficial lactic acid bacteria, including Lactobacillus, and Streptococcus in the gut, leading to an imbalance in the ratio of *Firmicutes* and *Bacteroidetes*, resulting in diseases such as gut permeability, insulin resistance, and obesity (Salazar et al., 2020; Ye et al., 2021). Therefore, finding suitable solid fat substitutes is particularly important.

Oleogel is a kind of viscoelasticity liquid or solid grease, which is mainly composed of a small amount of organic gel factors combined with fat or liquid oil. These factors can be self-assembled or recrystallized in liquid oil to form a three-dimensional network structure, which blocks the movement and spread of liquid oil, and making the whole system gel (Patel and Dewettinck, 2016). The oleogel provides a new idea to replace the traditional solid fats. At the same time, the introduced liquid oils can include flaxseed oil rich in n-3 long-chain polyunsaturated fatty acids, soybean oil rich in oleic acid, and camellia oil rich in natural antioxidants. These unsaturated fatty acids have beneficial effects on regulating the gut microbiota diversity, lowering the level of low-density lipoprotein in the blood, and regulating blood glucose (Jing et al., 2022; Ye et al., 2021).

The main functional role of fat in food formulation is to provide structure to the product, which including the textural and organoleptic properties and so on, and simply reducing the fat content in dairy products will seriously affect the quality of food products. Oleogel can not only effectively replace the fat content in food, but also the impact on product status and sensory quality is relatively small. For example, the incorporation of oleogel resulted in frankfurters with firmness, chewiness, and springiness comparable to those of pork fat formulations in another study (Wolfer et al., 2018), breads made with oleogel and triglyceryl monostearate had softer texture compared with breads made by commercial shortening (Mert and Demirkesen, 2016). Although the application technology of Oleogel in dairy products is not as mature and extensive as that in meat products and bakery products, dairy products are increasingly indispensable in people's daily life, oleogel is receiving a great deal of attention from researchers working in this field (Table 5) .

4. Action mechanism of different gel in dairy products

4.1. Hydrocolloids

The interaction between polysaccharide and milk protein in the dairy products is very complicated. The stability of dairy quality mainly relies on the interaction forces between polysaccharides and milk proteins, including covalent, electrostatic interaction (Lin et al., 2021; Sun et al., 2016), excluded volume (Svensson et al., 2014), hydrophobic interactions (Cheema et al., 2017), van der Waals forces (He et al., 2020). It can be affected by many factors, including polysaccharide structure, molecular weight and distribution, conformation, the milk protein type and concentration, the system pH, ironic strength, temperature and its processing process, heat treatment process, etc. Based on the polysaccharide structure, particularly the difference of net charges, polysaccharides can be divided into anionic, cationic and cationic. The effect of the polysaccharide classification on the formation of protein-polysaccharide complexes are discussed below.

Anionic polysaccharides, such as pectin, carrageenan, and xanthan gum, stabilizing the dairy matrix mainly base on the adsorption of polysaccharides on the surface of casein. Under acidic conditions, the carboxylate groups of pectin and the cationic amino acid residues on the casein are combined by electrostatic interaction (Huang et al., 2022; Wusigale et al., 2020). As it can effectively prevent protein precipitation and fat floating, it is often used as a stabilizer for yogurt. When the pH value (<5) decreases, more pectin can interact with casein electrostatically to form a complex, making the entire system more stable (Tan, 2019; Tromp et al., 2004). Carrageenan, another anionic hydrocolloids commonly used in neutral ice cream, is divided into three types such as λ-type, ι-type and κ-type. The three types can be adsorbed on the casein

Table 5
The influence of Oleogel on properties of dairy products at different conditions.

Category	Oleogel	Product type	Conditions	Results	References
Cheese	high-oleic soybean oil (HOSO) and rice bran wax	oleogel-cream-cheese (OCC)	OG sample was added to skim milk (76.58 %)	The fatty-acid profiles, antioxidant content, and the amount of oxidation products were comparable between the OCC and the ungelled cream-cheese sample (UGCC) products.	(Park et al., 2018)
	Canola oil with carnauba wax	imitation cheese low in saturated fat	The addition of oleogel is about 10 %	Oleogel produced cheese with harder and more cohesive/ chewy textures	(Moon et al., 2021)
	Soybean oil with rice bran wax (RBW) or sunflower wax (SW)	Processed cheese products (PCP)	Contains 10 % oleogel	The texture of PCP with 10 % oleogel(RBW) is harder, and the meltability is increase	(Huang et al., 2018)
Ice cream	refined sunflower oil with beeswax	Ice cream	90 g raw cream (50 % milk fat) or oleogel	Reduced the amount of saturated and long-chain fatty acids; organoleptic qualities deteriorated	(Ozdemir, 2023)
	soybean oil, with 6 % carnauba wax	Ice cream	50 %~100 % replacement of the traditional lipid	The replacement of oleogel fat (50 %) reduced the melting rate of ice cream, and sensory evaluations is acceptable	(Airoldi et al., 2022)
	Camellia oil with and beeswax	Ice cream	The amount of oleogel addition was 7 %	Compare with camellia oil ice cream and butter ice cream, the oleogel ice cream is better at overrun rate, melting rate and nutrition ingredients	(Jing et al., 2022)
	Strawberry seed oil with hydroxypropyl methylcellulose	Ice cream	Replace 5–7 % fat content	Rich in unsaturated fatty acids, a promising alternative	(Nazarewicz et al., 2023)
Cream	Isolated soy protein (ISP) and basil seed gum (ISP-BSG)	Cream	cream produced with reduced fat (5, 10 and 15 %)	5 % replacement had the most value of overall acceptance at texture and sensory test	(Naji-Tabasi et al., 2020)
	Myverol with high-oleic soybean oil (HOSO)	Filling cream	The addition of oleogel is 22 %, 26 %, 30 % and 40 %, respectively	26 % addition of oleogel made cream reduce oil migration and the texture is softer, at the same time, adhesiveness is enhanced	(Palla et al., 2021)
	Rapeseed oil and linseed oil with candelilla wax	vegan cream	Alternative fat content is 31.5 %	The physical properties of cream similar to commercial UHT dairy cream, and with greater physical stability	(Szymańska et al., 2021)
yogurt	Phytosterol and γ-oryzanol with sunflower oil	yogurt	Oleogel in water emulsion replace 2 % and 4 % fat	Perhaps due to the low-fat content, the yogurt network is not be well enhanced	(Moschakis et al., 2017)

micelles, so long as the charge carried by the carrageenan molecules reaches a certain strength. When the distance between two adjacent sulfonate groups on the carrageenan molecular chain is less than 0.5 nm, no matter what the molecular conformation and morphology of carrageenan, it can interact with casein micelles. λ-type carrageenan has the highest charge density, and the average distance between two sulfonate groups is 0.3 nm so that it can be adsorbed on casein micelles at any temperature (Langendorff et al., 2000). Most studies have considered that only λ-type carrageenan can better bind to casein, but Tan reported that the charge on carrageenan was large enough, any carrageenan can attach to casein (Tan, 2019). Figure S2 shows a schematic diagram of the interaction between polysaccharides and proteins.

Guar gum is a cationic hydrocolloid and has a linear macromolecular structure. It is biocompatible and non-toxic used in food product. The gel texture adding guar gum is hard, while locust bean gum is too soft. The combination of the two can improve the texture of dairy product, and then make the dairy foods to be more acceptable.

Locust bean gum, inulin, and starch/modified starch are among the most used non-ionic polysaccharides (Cui et al., 2014). Although the application range of nonionic polysaccharides is not as wide as that of anionic polysaccharides, it has also attracted widespread attention in the dairy product procession due to its whey absorption effect, ability of prevention casein aggregating and function of improving the stability (Kale et al., 2020; Pancar et al., 2016; Prasad et al., 2013; Rinaldoni et al., 2012; Schmidt et al., 2001; Sun et al., 2016). Otherwise, large modified starch granules can mimic fat properties in dairy product. Interactions between proteins and non-ionic polysaccharides are common owing to their neutral characteristic. Phosphorylated starches are a kind of starch derivatives with lots of anionic charges due to the introduction of the phosphate groups and can overcome the deficiencies of unmodified starch (Sun et al., 2016). Phosphate starch possessed better adsorption ability, which made it combine tightness with casein. It was observed that phosphate starch-casein was bound firmly together via electrostatic repulsion, steric stabilization and hydrogen bonds (Sun et al., 2016). Apart from -PO_4 in phosphorylated starches, the -SO_4, –COOH, –OH in polysaccharides and –COOH, –NH_2, –OH in proteins can form hydrogen bonds.

4.2. Oleogel

As a viscoelastic solid, oleogel captures hydrophobic liquid vegetable oil into a thermo reversible three-dimensional gel network through hydrogen bonding, electrostatic and other interactions, so that the content of oil can reach 90 ~ 96 % (Frolova et al., 2022; Singh et al., 2017).

The common preparation methods mainly include direct dispersion and indirect dispersion, as shown in Fig. 1 (A). The direct method is to disperse the gelator directly into the oil phase under high temperature heating and stirring, followed by cooling it under relatively mild conditions to induce the formation of nucleation and crystal growth, resulting the completion of self-assembly networks(Cui et al., 2023); The indirect approach is mainly to forming a structural skeleton by adding gelator to the aqueous solvent or water continuous emulsion under stirring, which requires the careful removal of aqueous phase for the formation of the network structure of oleogel by oven drying or freeze-drying. The indirect methods have better entrapment and preservation effects on liquid oils to compared with direct method (Patel and Dewettinck, 2016).

Therefore, it has the appearance of solid fat and the interior of liquid fat, and it has functions equivalent to solid fat, and contains less *trans*-fat and saturated fat (Manzoor et al., 2022). It can provide the creaminess and smoothness taste required for cream and ice cream, and transforming liquid oils into solid fats without formation of *trans*-fatty acids to reduce levels of saturated fatty acids, replacing solid fat in cream, ice cream, yogurt, and cheese. Furthermore, oleogel can also be applied in meat products, flour products, and nutrition delivery (Mert and Demirkesen, 2016; Wolfer et al., 2018; Zhuang et al., 2021). It is worth mentioning that in nutrition delivery, oleogel can encapsulate nutrients and probiotics for application in dairy products, serving as a delivery carrier to protect nutrients and probiotics, thereby enhancing its storage stability and intestinal survival rate (Zhuang et al., 2021). Fig. 1(B) shows the application cases of oleogel in several different dairy products and other foods.

5. Conclusion and future remarks

The position of dairy products in life cannot be ignored. This paper

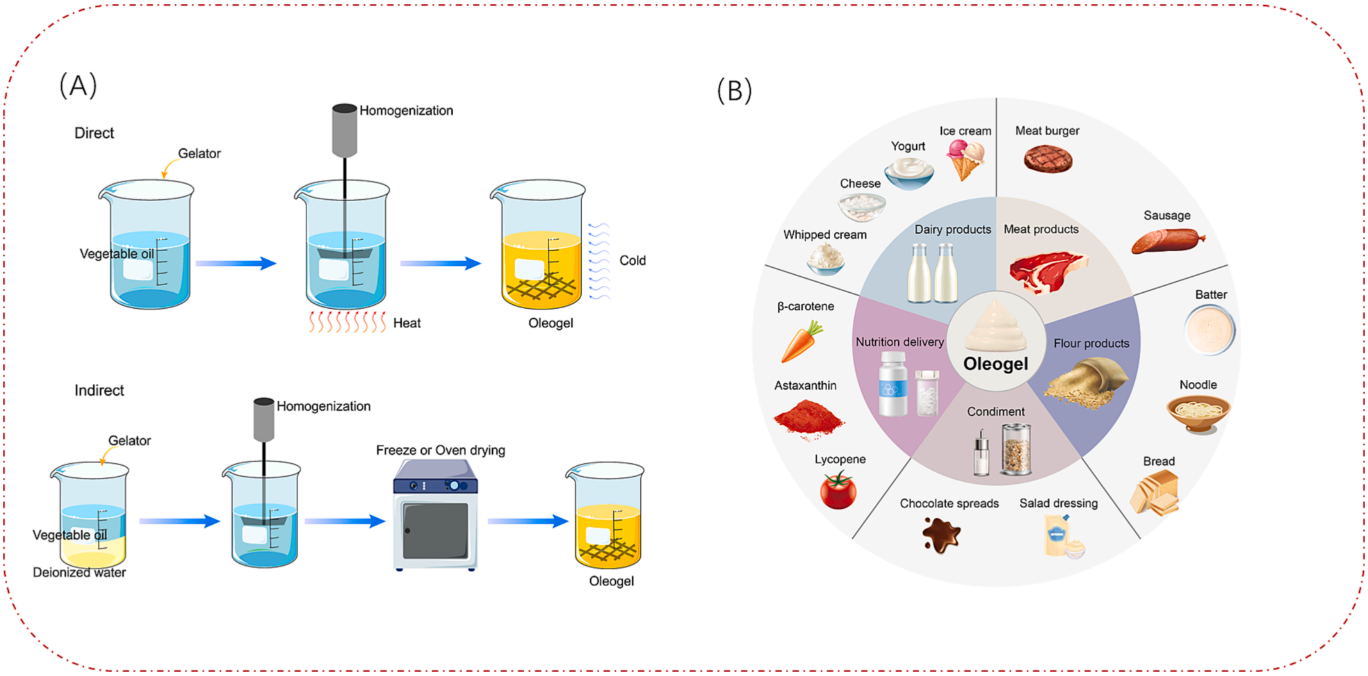


Fig. 1. (A) Two common preparation methods of oleogel; (B)The application cases of oleogel in dairy products and other foods.

reviews the application research of different hydrocolloids and oleogel in yogurt, cheese, ice cream and whipped cream as the common dairy products, the interaction and functional characteristics were list as well. The hydrocolloids can readily disperse, and swell and combine with the free water, so that they interact with milk proteins to improve the texture of dairy foods. The oleogel can improve the composition of good fatty acids in dairy products by fat replacement. Hydrocolloids and oleogel are the promising ingredient in the development of dairy foods, which can not only improve the technical function, but also improve the composition and structure of milk fat in dairy foods.

Nevertheless, there are many challenges and technological problems that prevent the application of hydrocolloids and oleogel in dairy foods. In practical application, hydrocolloids will be affected by temperature, pH, steam and other factors in dairy processing, which will lead to an unsatisfactory effect. However, the problems faced by oleogel are more complex. The commercialization of oleogel has not enough data support, mostly due to the lack of more theoretical grounding and insufficient experimental attempts on dairy products. For example, how to select the ideal materials suitable for dairy products, including the selection of liquid and gelator and their proportion, the processing method and storage conditions and so on, these are all problems they face and need to solve so as to promote the application in dairy products. Although many factors affect the quality of protein-polysaccharide interactions and the fat substitution effect of oleogel in dairy products, if future studies focus on solving the above problems, the commercial application of hydrocolloids and oleogel in dairy products will be better developed.

CRediT authorship contribution statement

Shan Zhang: Writing – original draft, Visualization. **Chuanying Ren:** Supervision, Project administration, Funding acquisition. **Caiyun Wang:** Supervision, Conceptualization. **Renjiao Han:** Writing – review & editing, Supervision. **Siyu Xie:** Writing – review & editing, Visualization, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

Acknowledgements

This work was supported by National Key Research and Development Program of China (2021YFD2100902), National Rice Industry Technology System, China (CARS-01-50), Heilongjiang Provincial Agricultural Science and Technology Innovation and Leaping Project, China (CX23GG16).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.fochx.2024.101215.

References

Airoldi, R., da Silva, T. L. T., Ract, J. N. R., Foguel, A., Colleran, H. L., Ibrahim, S. A., & da Silva, R. C. (2022). Potential use of carnauba wax oleogel to replace saturated fat in ice cream. *Journal of the American Oil Chemists' Society, 99*(11), 1085–1099. https://doi.org/10.1002/aocs.12652

Akalın, A. S., Karagözlü, C., & Ünal, G. (2007). Rheological properties of reduced-fat and low-fat ice cream containing whey protein isolate and inulin. *European Food Research and Technology, 227*(3), 889–895. https://doi.org/10.1007/s00217-007-0800-z

Al-Zoreky, N. S., & Al-Otaibi, M. M. (2015). Suitability of camel milk for making yogurt. *Food Science and Biotechnology, 24*(2), 601–606. https://doi.org/10.1007/s10068-015-0078-z

Arioui, F., Ait Saada, D., & Cheriguene, A. (2017). Physicochemical and sensory quality of yogurt incorporated with pectin from peel of Citrus sinensis. *Food Science & Nutrition, 5*(2), 358–364. https://doi.org/10.1002/fsn3.400

Athari, B., Nasirpour, A., Saeidy, S., & Esehaghbeygi, A. (2021). Physicochemical properties of whipped cream stabilized with electrohydrodynamic modified cellulose. *Journal of Food Processing and Preservation, 45*(9), e15688.

Aziznia, S., Khosrowshahi, A., Madadlou, A., & Rahimi, J. (2008). Whey protein concentrate and gum tragacanth as fat replacers in nonfat yogurt: Chemical, physical, and microstructural properties. *Journal of Dairy Science, 91*(7), 2545–2552. https://doi.org/10.3168/jds.2007-0875

Aziznia, S., Khosrowshahi, A., Madadlou, A., Rahimi, J., & Abbasi, H. (2009). Texture of nonfat yoghurt as influenced by whey protein concentrate and Gum Tragacanth as fat replacers. *International Journal of Dairy Technology, 62*(3), 405–410. https://doi.org/10.1111/j.1471-0307.2009.00507.x

Bahramparvar, M., Haddad Khodaparast, M. H., & Razavi, S. M. A. (2009). The effect of Lallemantia royleana(Balangu) seed, palmate-tuber salep and carboxymethylcellulose gums on the physicochemical and sensory properties of typical soft ice cream. *International Journal of Dairy Technology, 62*(4), 571–576. https://doi.org/10.1111/j.1471-0307.2009.00526.x

BahramParvar, M., Mazaheri Tehrani, M., & Razavi, S. M. A. (2013). Effects of a novel stabilizer blend and presence of κ-carrageenan on some properties of vanilla ice cream during storage. *Food Bioscience, 3*, 10–18. https://doi.org/10.1016/j.fbio.2013.05.001

Bermudez-Beltrán, K. A., Marzal-Bolaño, J. K., Olivera-Martínez, A. B., & Espitia, P. J. P. (2020). Cape gooseberry Petit Suisse Cheese incorporated with moringa leaf powder and gelatin. *Lwt, 123*, Article 109101. https://doi.org/10.1016/j.lwt.2020.109101

Biglarian, N., Rafe, A., & Shahidi, S. A. (2021). Effect of basil seed gum and kappa-carrageenan on the rheological, textural, and structural properties of whipped cream. *Journal of the Science of Food and Agriculture, 101*(14), 5851–5860. https://doi.org/10.1002/jsfa.11237

Bondoc, I. & Șindilar, E.V. (2002). Veterinary sanitary control of food quality and hygiene (Controlul sanitar veterinar al calit̆ații și salubrit̆ații alimentelor - Original Title). Vol. I. "Ion Ionescu de la Brad" Ias¸i Publishing, ISBN 973-8014-64-6, pp. 151-166.

Bondoc, I. (2007). Technology and quality control of milk and dairy products (Tehnologia și controlul calității laptelui și produselor lactate - Original Title). Vol. I. "Ion Ionescu de la Brad" Iași Publishing, ISBN 978-973-7921-97-0, pp. 1-159.

Brighenti, M., Govindasamy-Lucey, S., Jaeggi, J. J., Johnson, M. E., & Lucey, J. A. (2020). Behavior of stabilizers in acidified solutions and their effect on the textural, rheological, and sensory properties of cream cheese. *Journal of Dairy Science, 103*(3), 2065–2076. https://doi.org/10.3168/jds.2019-17487

Camacho, M. M., Martínez-Navarrete, N., & Chiralt, A. (2005). Rheological characterization of experimental dairy creams formulated with locust bean gum (LBG) and λ-carrageenan combinations. *International Dairy Journal, 15*(3), 243–248. https://doi.org/10.1016/j.idairyj.2004.07.008

Camacho, M. M., Martínez-Navarrete, N., & Chiralt, A. (2001). Stability of whipped dairy creams containing locust bean gum/λ-carrageenan mixtures during freezing–thawing processes. *Food Research International, 34*(10), 887–894. https://doi.org/10.1016/S0963-9969(01)00113-2

Černíková, M., Buňka, F., Pospiech, M., Tremlová, B., Hladká, K., Pavlínek, V., & Březina, P. (2010). Replacement of traditional emulsifying salts by selected hydrocolloids in processed cheese production. *International Dairy Journal, 20*(5), 336–343. https://doi.org/10.1016/j.idairyj.2009.12.012

Cheema, M., Hristov, A. N., & Harte, F. M. (2017). The binding of orally dosed hydrophobic active pharmaceutical ingredients to casein micelles in milk. *Journal of Dairy Science, 100*(11), 8670–8679. https://doi.org/10.3168/jds.2017-12631

Cooke, D. R., Khosrowshahi, A., & McSweeney, P. L. H. (2012). Effect of gum tragacanth on the rheological and functional properties of full-fat and half-fat Cheddar cheese. *Dairy Science & Technology, 93*(1), 45–62. https://doi.org/10.1007/s13594-012-0088-z

Cropper, S. L., Kocaoglu-Vurma, N. A., Tharp, B. W., & Harper, W. J. (2013). Effects of locust bean gum and mono- and diglyceride concentrations on particle size and melting rates of ice cream. *Journal of Food Science, 78*(6), C811–C816. https://doi.org/10.1111/1750-3841.12073

Cui, B., Lu, Y. M., Tan, C. P., Wang, G. Q., & Li, G. H. (2014). Effect of cross-linked acetylated starch content on the structure and stability of set yoghurt. *Food Hydrocolloids, 35*, 576–582. https://doi.org/10.1016/j.foodhyd.2013.07.018

Cui, B., Tan, C., Lu, Y., Liu, X., & Li, G. (2014). The interaction between casein and hydroxypropyl distarch phosphate (HPDSP) in yoghurt system. *Food Hydrocolloids, 37*, 111–115. https://doi.org/10.1016/j.foodhyd.2013.10.032

Cui, X., Saleh, A., Yang, S., Wang, N., Wang, P., Xiao, Z., & Saleh, S. (2023). Oleogels as Animal Fat and Shortening Replacers: Research Advances and Application Challenges. *Food Reviews, 39*(8): 5233-5254. *International*. https://doi.org/10.1080/87559129.2022.2062769.

De Kruif, C. G., & Tuinier, R. (2001). Polysaccharide protein interactions. *Food Hydrocolloids, 15*(4), 555–563. https://doi.org/10.1016/S0268-005X(01)00076-5

Diamantino, V. R., Costa, M. S., Taboga, S. R., Vilamaior, P. S. L., Franco, C. M. L., & Penna, A. L. B. (2019). Starch as a potential fat replacer for application in cheese: Behaviour of different starches in casein/starch mixtures and in the casein matrix. *International Dairy Journal, 89*, 129–138. https://doi.org/10.1016/j.idairyj.2018.08.015

Dogan, M., Kayacier, A., Toker, Ö. S., Yilmaz, M. T., & Karaman, S. (2012). Steady, Dynamic, Creep, and Recovery Analysis of Ice Cream Mixes Added with Different

Concentrations of Xanthan Gum. *Food and Bioprocess Technology, 6*(6), 1420–1433. https://doi.org/10.1007/s11947-012-0872-z

El-Nagar, G., Clowes, G., Tudorică, C. M., Kuri, V., & Brennan, C. S. (2002). Rheological quality and stability of yog-ice cream with added inulin. *International Journal of Dairy Technology, 55*(2), 89–93. https://doi.org/10.1046/j.1471-0307.2002.00042.x

Everett, D. W., & McLeod, R. E. (2005). Interactions of polysaccharide stabilisers with casein aggregates in stirred skim-milk yoghurt. *International Dairy Journal, 15*(11), 1175–1183. https://doi.org/10.1016/j.idairyj.2004.12.004

Frolova, Y., Sarkisyan, V., Sobolev, R., Makarenko, M., Semin, M., & Kochetkova, A. (2022). The influence of edible oil's composition on the properties of beeswax-based oleogels. *Gels, 8*(1), 48. https://doi.org/10.3390/gels8010048

Gafour, W., & Aly, E. (2020). Organoleptic, textural and whipping properties of whipped cream with different stabilizer blends [pdf]. *Acta Scientiarum Polonorum Technologia Alimentaria, 19*(4), 425–433. https://doi.org/10.17306/j.Afs.2020.0784

Ghosh, A. K., & Bandyopadhyay, P. (2012). Polysaccharide-protein interactions and their relevance in food colloids. *The Complex World of Polysaccharides, 14*, 395–406. https://doi.org/10.5772/50561

Ghribi, A. M., Zouari, M., Attia, H., & Besbes, S. (2021). Study of protein / k-carrageenan mixture's effect on low-fat whipping cream formulation. *Lwt, 147*, Article 111647. https://doi.org/10.1016/j.lwt.2021.111647

Gilbert, A., Rioux, L. E., St-Gelais, D., & Turgeon, S. L. (2020). Characterization of syneresis phenomena in stirred acid milk gel using low frequency nuclear magnetic resonance on hydrogen and image analyses. *Food Hydrocolloids, 106*, Article 105907. https://doi.org/10.1016/j.foodhyd.2020.105907

Güler-Akın, M. B., Goncu, B., & Akın, M. S. (2018). Some properties of bio-yogurt enriched with cellulose fiber. *Advances in Microbiology, 8*(01), 54–64. https://doi.org/10.4236/aim.2018.81005

Guven, M., Karaca, O. B., & Kacar, A. (2003). The effects of the combined use of stabilizers containing locust bean gum and of the storage time on Kahramanmaraş-type ice creams. *International Journal of Dairy Technology, 56*(4), 223–228. https://doi.org/10.1046/j.1471-0307.2003.00108.x

Gyawali, R., & Ibrahim, S. A. (2018). Addition of pectin and whey protein concentrate minimises the generation of acid whey in Greek-style yogurt. *The Journal of Dairy Research, 85*(2), 238–242. https://doi.org/10.1017/S0022029918000109

Hanáková, Z., Buňka, F., Pavlínek, V., Hudečková, L., & Janiš, R. (2013). The effect of selected hydrocolloids on the rheological properties of processed cheese analogues made with vegetable fats during the cooling phase. *International Journal of Dairy Technology, 66*(4), 484–489. https://doi.org/10.1111/1471-0307.12066

He, C., Hu, Y., Liu, Z., Woo, M. W., Xiong, H., & Zhao, Q. (2020). Interaction between casein and rice glutelin: Binding mechanisms and molecular assembly behaviours. *Food Hydrocolloids, 107*, Article 105967. https://doi.org/10.1016/j.foodhyd.2020.105967

He, J., Han, Y., Liu, M., Wang, Y., Yang, Y., & Yang, X. (2019). Effect of 2 types of resistant starches on the quality of yogurt. *Journal of Dairy Science, 102*(5), 3956–3964. https://doi.org/10.3168/jds.2018-15562

Huang, H., Hallinan, R., & Maleky, F. (2018). Comparison of different oleogels in processed cheese products formulation. *International Journal of Food Science & Technology, 53*(11), 2525–2534. https://doi.org/10.1111/ijfs.13846

Huang, J.-Y., Jones, O. G., & Zhang, B. Y. (2022). Interactions of casein and carrageenan with whey during pasteurization and their effects on protein deposition. *Food and Bioproducts Processing, 135*, 1–10. https://doi.org/10.1016/j.fbp.2022.06.002

Hussain, M., Bakalis, S., Gouseti, O., Akhtar, S., Hameed, A., & Ismail, A. (2017). Microstructural and dynamic oscillatory aspects of yogurt as influenced by hydrolysed guar gum. *International Journal of Food Science & Technology, 52*(10), 2210–2216. https://doi.org/10.1111/ijfs.13500

Jagdish, K. S., Arvind, R. S., Deepak, O. S., & Ashok, B. R. (2014). Effect of guar gum on viscosity of ice cream. *Asian Journal of Dairy and Food Research, 33*(4), 259–262. https://doi.org/10.5958/0976-0563.2014.00614.9

Jana, A. H., Patel, H. G., Suneeta, P., & Prajapati, J. P. (2010). Quality of casein based Mozzarella cheese analogue as affected by stabilizer blends. *Journal of Food Science and Technology, 47*(2), 240–242. https://doi.org/10.1007/s13197-010-0034-0

Javidi, F., Razavi, S. M. A., Behrouzian, F., & Alghooneh, A. (2016). The influence of basil seed gum, guar gum and their blend on the rheological, physical and sensory properties of low fat ice cream. *Food Hydrocolloids, 52*, 625–633. https://doi.org/10.1016/j.foodhyd.2015.08.006

Jing, X., Chen, Z., Tang, Z., Tao, Y., Huang, Q., Wu, Y., & Sun, Y. (2022). Preparation of camellia oil oleogel and its application in an ice cream system. *LWT, 169*, Article 113985. https://doi.org/10.1016/j.lwt.2022.113985

Kale, R., Md, S., Gs, R., & Vr, C. (2020). Use of enzyme modified sweet potato starch in formulation of ice cream. *International Journal of Chemical Studies, 8*, 3002–3008. https://doi.org/10.22271/chemi.2020.v8.i4aj.10110

Khanal, B. K. S., Bhandari, B., Prakash, S., Liu, D., Zhou, P., & Bansal, N. (2018). Modifying textural and microstructural properties of low fat Cheddar cheese using sodium alginate. *Food Hydrocolloids, 83*, 97–108. https://doi.org/10.1016/j.foodhyd.2018.03.015

Kiani, H., Mousavi, M., Razavi, E., & Oxford, R. J. F. H. (2010). Effect of gellan, alone and in combination with high-methoxy pectin, on the structure and stability of doogh, a yogurt-based Iranian drink. *Food Hydrocolloids, 24*(8), 744–754. https://doi.org/10.1016/j.foodhyd.2010.03.016

Klein, M., Aserin, A., Svitov, I., & Garti, N. (2010). Enhanced stabilization of cloudy emulsions with gum Arabic and whey protein isolate. *Colloids and Surfaces. B, Biointerfaces, 77*(1), 75–81. https://doi.org/10.1016/j.colsurfb.2010.01.008

Konuklar, G., Inglett, G. E., Warner, K., & Carriere, C. J. (2004). Use of a β-glucan hydrocolloidal suspension in the manufacture of low-fat Cheddar cheeses: Textural properties by instrumental methods and sensory panels. *Food Hydrocolloids, 18*(4), 535–545. https://doi.org/10.1016/j.foodhyd.2003.08.010

Korish, M., & Abd Elhamid, A. M. (2012). Improving the textural properties of Egyptian kariesh cheese by addition of hydrocolloids. *International Journal of Dairy Technology, 65*(2), 237–242. https://doi.org/10.1111/j.1471-0307.2011.00818.x

Kováčová, R., Štětina, J., & Čurda, L. (2010). Influence of processing and κ-carrageenan on properties of whipping cream. *Journal of Food Engineering, 99*(4), 471–478. https://doi.org/10.1016/j.jfoodeng.2010.02.010

Kurt, A., Cengiz, A., & Kahyaoglu, T. (2016). The effect of gum tragacanth on the rheological properties of salep based ice cream mix. *Carbohydrate Polymers, 143*, 116–123. https://doi.org/10.1016/j.carbpol.2016.02.018

Lal, S. N., O'Connor, C. J., & Eyres, L. (2006). Application of emulsifiers/stabilizers in dairy products of high rheology. *Advances in Colloid and Interface Science, 123*, 433–437. https://doi.org/10.1016/j.cis.2006.05.009

Langendorff, V., Cuvelier, G., Michon, C., Launay, B., Parker, A., & De kruif, C. G. (2000). Effects of carrageenan type on the behaviour of carrageenan/milk mixtures. *Food Hydrocolloids, 14*(4), 273–280. https://doi.org/10.1016/S0268-005X(99)00064-8

Lashkari, H., Khosrowshahi Asl, A., Madadlou, A., & Alizadeh, M. (2014). Chemical composition and rheology of low-fat Iranian white cheese incorporated with guar gum and gum arabic as fat replacers. *Journal of Food Science and Technology, 51*(10), 2584–2591. https://doi.org/10.1007/s13197-012-0768-y

Li, H., Liu, Y., Sun, Y., Li, H., & Yu, J. (2019). Properties of polysaccharides and glutamine transaminase used in mozzarella cheese as texturizer and crosslinking agents. *LWT, 99*, 411–416. https://doi.org/10.1016/j.lwt.2018.10.011

Lin, L., Oh, H. E., Deeth, H. C., & Wong, M. (2021). The effects of casein and whey proteins on the rheological properties of calcium-induced skim milk gels. *International Dairy Journal, 113*, Article 104893. https://doi.org/10.1016/j.idairyj.2020.104893

Lobato-Calleros, C., Ramírez-Santiago, C., Vernon-Carter, E. J., & Alvarez-Ramirez, J. (2014). Impact of native and chemically modified starches addition as fat replacers in the viscoelasticity of reduced-fat stirred yogurt. *Journal of Food Engineering, 131*, 110–115. https://doi.org/10.1016/j.jfoodeng.2014.01.019

Ma, Y., Liu, W. W., & Meng, X. J. (2014). Manufacturing Research with SBOS Ice Cream of Goat Milk Processing. *Advanced Materials Research, 1056*, 75–79. https://doi.org/10.4028/www.scientific.net/AMR.1056.75

Macků, I., Buňka, F., Pavlínek, V., Leciánová, P., & Hrabě, J. (2008). The effect of pectin concentration on viscoelastic and sensory properties of processed cheese. *International Journal of Food Science & Technology, 43*(9), 1663–1670. https://doi.org/10.1111/j.1365-2621.2008.01734.x

Manzoor, S., Masoodi, F. A., Naqash, F., & Rashid, R. (2022). Oleogels: Promising alternatives to solid fats for food applications. *Food Hydrocolloids for Health, 2*, Article 100058. https://doi.org/10.1016/j.fhfh.2022.100058

Martín-Martínez, E. S., Aguilar-Méndez, M. A., Espinosa-Solares, T., Pless, R. C., & Quintana, Z. D. (2004). Starch Phosphates Produced by Extrusion: Physical Properties and Influence on Yogurt Stability. *Starch - Stärke, 56*(5), 199–207. https://doi.org/10.1002/star.200300212

Martinez, C. O., Pereira Ruiz, S., Carvalho Fenelon, V., Rodrigues de Morais, G., Luciano Baesso, M., Matioli, G. J. J. o. t. S. o. F., & Agriculture. (2016). Characterization of curdlan produced by Agrobacterium sp. IFO 13140 cells immobilized in a loofa sponge matrix, and application of this biopolymer in the development of functional yogurt. *96*(7), 2410-2417. https://doi.org/ https://doi.org/10.1002/jsfa.7357.

Mert, B., & Demirkesen, I. (2016). Reducing saturated fat with oleogel/shortening blends in a baked product. *Food Chemistry, 199*, 809–816. https://doi.org/10.1016/j.foodchem.2015.12.087

Mezzenga, R., Schurtenberger, P., Burbidge, A., & Michel, M. (2005). Understanding foods as soft materials. *Nature Materials, 4*(10), 729–740. https://doi.org/10.1038/nmat1496

Moon, K., Choi, K.-O., Jeong, S., Kim, Y.-W., & Lee, S. (2021). Solid Fat Replacement with Canola Oil-Carnauba Wax Oleogels for Dairy-Free Imitation Cheese Low in Saturated Fat. *Foods, 10*(6), 1351. https://doi.org/10.3390/foods10061351

Morell, P., Hernando, I., Llorca, E., & Fiszman, S. (2015). Yogurts with an increased protein content and physically modified starch: Rheological, structural, oral digestion and sensory properties related to enhanced satiating capacity. *Food Research International, 70*, 64–73. https://doi.org/10.1016/j.foodres.2015.01.024

Moriano, M. E., & Alamprese, C. (2017). Organogels as novel ingredients for low saturated fat ice creams. *LWT, 86*, 371–376. https://doi.org/10.1016/j.lwt.2017.07.034

Moschakis, T., Dergiade, I., Lazaridou, A., Biliaderis, C. G., & Katsanidis, E. (2017). Modulating the physical state and functionality of phytosterols by emulsification and organogel formation: Application in a model yogurt system. *Journal of Functional Foods, 33*, 386–395. https://doi.org/10.1016/j.jff.2017.04.007

Mudgil, P., Jumah, B., Ahmad, M., Hamed, F., & Maqsood, S. (2018). Rheological, micro-structural and sensorial properties of camel milk yogurt as influenced by gelatin. *LWT, 98*, 646–653. https://doi.org/10.1016/j.lwt.2018.09.008

Murayama, D., Rankin, S. A., & Ikeda, S. (2021). Effect of surfactant-induced competitive displacement of whey protein conjugated to acid- or alkali-extracted potato pectin on emulsion stability. *Food Hydrocolloids, 114*, Article 106558. https://doi.org/10.1016/j.foodhyd.2020.106558

Naji-Tabasi, S., Mahdian, E., Arianfar, A., & Naji-Tabasi, S. (2020). Investigation of Oleogel Properties Prepared by Pickering Emulsion-Templated Stabilized with Solid Particles of Basil Seed Gum and Isolated Soy Protein as a Fat Substitute in Cream. *Research and Innovation in Food Science and Technology, 9*(3), 269–282. https://doi.org/10.22101/JRIFST.2020.229269.1168

Nateghi, L., Roohinejad, S., Totosaus, A., Rahmani, A., Tajabadi, N., Meimandipour, A., & Abd Manap, Y. (2012). Physicochemical and textural properties of reduced fat Cheddar cheese formulated with xanthan gum and/or sodium caseinate as fat replacers. *Journal of Food Agriculture and Environment, 10*, 59–63.

Nazarewicz, S., Kozłowicz, K., Gładyszewska, B., Rząd, K., Matwijczuk, A., Kobus, Z., & Skrzypek, T. (2023). Effects of Ultrasound Treatment on the Physical and Chemical Properties of Ice Cream with a Strawberry Seed Oil Oleogel. *Sustainability, 15*(11), 8975. https://doi.org/10.3390/su15118975

Nikitina, E., Ahmad Riyanto, R., Vafina, A., Yurtaeva, T., & Tsyganov, G. E. M. (2019). Effect of fermented modified potato starches to low-fat yogurt. *Journal of Food and Nutrition Research, 7*(7), 549–553. https://doi.org/10.12691/jfnr-7-7-10

Okesola, B. O., Vieira, V. M. P., Cornwell, D. J., Whitelaw, N. K., & Smith, D. K. (2015). 1,3:2,4-Dibenzylidene-d-sorbitol (DBS) and its derivatives – efficient, versatile and industrially-relevant low-molecular-weight gelators with over 100 years of history and a bright future. *Soft Matter, 11*(24), 4768–4787. https://doi.org/10.1039/C5SM00845J

Okuro, P. K., Martins, A. J., Vicente, A. A., & Cunha, R. L. (2020). Perspective on oleogelator mixtures, structure design and behaviour towards digestibility of oleogels. *Current Opinion in Food Science, 35*, 27–35. https://doi.org/10.1016/j.cofs.2020.01.001

Ozdemir, C. (2023). An Investigation of Several Physicochemical Characteristics, as well as the Fatty Acid Profile of Ice Cream Samples Containing Oleogel, Various Stabilizers, and Emulsifiers. *Gels, 9*(7), 543. https://doi.org/10.3390/gels9070543

Palla, C. A., Wasinger, M. F., & Carrín, M. E. (2021). Monoglyceride oleogels as fat replacers in filling creams for sandwich cookies. *Journal of the Science of Food and Agriculture, 101*(6), 2398–2405. https://doi.org/10.1002/jsfa.10863

Pancar, E. D., Andiç, S., & Boran, G. (2016). Comparative Effects of Fish and Cow Gelatins and Locust Bean Gum on Chemical, Textural, and Sensory Properties of Yogurt. *Journal of Aquatic Food Product Technology, 25*(6), 843–853. https://doi.org/10.1080/10498850.2014.944293

Pang, Z., Deeth, H., Yang, H., Prakash, S., & Bansal, N. (2017). Evaluation of tilapia skin gelatin as a mammalian gelatin replacer in acid milk gels and low-fat stirred yogurt. *Journal of Dairy Science, 100*(5), 3436–3447. https://doi.org/10.3168/jds.2016-11881

Pang, Z., Xu, R., Luo, T., Che, X., Bansal, N., & Liu, X. (2019). Physiochemical properties of modified starch under yogurt manufacturing conditions and its relation to the properties of yogurt. *Journal of Food Engineering, 245*, 11–17. https://doi.org/10.1016/j.jfoodeng.2018.10.003

Park, C., Bemer, H. L., & Maleky, F. (2018). Oxidative Stability of Rice Bran Wax Oleogels and an Oleogel Cream Cheese Product. *Journal of the American Oil Chemists' Society, 95*(10), 1267–1275. https://doi.org/10.1002/aocs.12095

Patel, A. R., & Dewettinck, K. (2016). Edible oil structuring: An overview and recent updates. *Food & function, 7*(1), 20–29. https://doi.org/10.1039/c5fo01006c

Patel, A. R., Nicholson, R. A., & Marangoni, A. G. (2020). Applications of fat mimetics for the replacement of saturated and hydrogenated fat in food products. *Current Opinion in Food Science, 33*, 61–68. https://doi.org/10.1016/j.cofs.2019.12.008

Patmore, J. V., Goff, H. D., & Fernandes, S. (2003). Cryo-gelation of galactomannans in ice cream model systems. *Food Hydrocolloids, 17*(2), 161–169. https://doi.org/10.1016/S0268-005X(02)00048-6

Prasad, L. N., Sherkat, F., & Shah, N. P. (2013). Influence of galactooligosaccharides and modified waxy maize starch on some attributes of yogurt. *Journal of Food Science, 78*(1), M77–M83. https://doi.org/10.1111/j.1750-3841.2012.03004.x

Rafiq, L., Zahoor, T., Sagheer, A., Khalid, N., Rahman, U. U., & Liaqat, A. (2020). Augmenting yogurt quality attributes through hydrocolloidal gums. *Asian-Australas J Anim Sci, 33*(2), 323–331. https://doi.org/10.5713/ajas.18.0218

Rahimi, J., Khosrowshahi, A., Madadlou, A., & Aziznia, S. (2007). Texture of low-fat Iranian White cheese as influenced by gum tragacanth as a fat replacer. *Journal of Dairy Science, 90*(9), 4058–4070. https://doi.org/10.3168/jds.2007-0121

Ramaswamy, H. S., & Basak, S. (1992). Pectin and Raspberry Concentrate Effects on the Rheology of Stirred Commercial Yogurt. *Journal of Food Science, 57*(2), 357–360. https://doi.org/10.1111/j.1365-2621.1992.tb05494.x

Rezvani, F., Abbasi, H., & Nourani, M. (2020). Effects of protein–polysaccharide interactions on the physical and textural characteristics of low-fat whipped cream. *Journal of Food Processing and Preservation, 44*(10), e14743.

Rinaldoni, A. N., Campderrós, M. E., & Pérez Padilla, A. (2012). Physico-chemical and sensory properties of yogurt from ultrafiltreted soy milk concentrate added with inulin. *LWT - Food Science and Technology, 45*(2), 142–147. https://doi.org/10.1016/j.lwt.2011.09.009

Salazar, J., Angarita, L., Morillo, V., Navarro, C., Martínez, M. S., Chacín, M., & Bermudez, V. (2020). Microbiota and Diabetes Mellitus: Role of Lipid Mediators. *Nutrients, 12*(10), 3039. https://doi.org/10.3390/nu12103039

Samakradhamrongthai, R. S., Jannu, T., Supawan, T., Khawsud, A., Aumpa, P., & Renaldi, G. (2021). Inulin application on the optimization of reduced-fat ice cream using response surface methodology. *Food Hydrocolloids, 119*, Article 106873. https://doi.org/10.1016/j.foodhyd.2021.106873

Sandoval-Castilla, O., Lobato-Calleros, C., Aguirre-Mandujano, E., & Vernon-Carter, E. J. (2004). Microstructure and texture of yogurt as influenced by fat replacers. *International Dairy Journal, 14*(2), 151–159. https://doi.org/10.1016/S0958-6946(03)00166-3

Schmidt, K. A., & Herald, T. J. (2001). Modified wheat starches used as stabilizers in set-style yogurt. *Journal of Food Quality, 24*(5), 421–434. https://doi.org/10.1111/j.1745-4557.2001.tb00620.x

Seo, C. W., & Oh, N. S. (2022). Functional application of Maillard conjugate derived from a κ-carrageenan/milk protein isolate mixture as a stabilizer in ice cream. *LWT, 161*, Article 113406. https://doi.org/10.1016/j.lwt.2022.113406

Shiroodi, S. G., Mohammadifar, M. A., Gorji, E. G., Ezzatpanah, H., & Zohouri, N. (2012). Influence of gum tragacanth on the physicochemical and rheological properties of kashk. *The Journal of Dairy Research, 79*(1), 93–101. https://doi.org/10.1017/S0022029911000872

Singh, A., Auzanneau, F. I., & Rogers, M. A. (2017). Advances in edible oleogel technologies – A decade in review. *Food Research International, 97*, 307–317. https://doi.org/10.1016/j.foodres.2017.04.022

Skryplonek, K., Henriques, M., Gomes, D., Viegas, J., Fonseca, C., Pereira, C., & Mituniewicz-Malek, A. (2019). Characteristics of lactose-free frozen yogurt with kappa-carrageenan and corn starch as stabilizers. *Journal of Dairy Science, 102*(9), 7838–7848. https://doi.org/10.3168/jds.2019-16556

Sobti, B., Mbye, M., Alketbi, H., Alnaqbi, A., Alshamisi, A., Almeheiri, M., & Kamal-Eldin, A. (2020). Rheological characteristics and consumer acceptance of camel milk yogurts as affected by bovine proteins and hydrocolloids. *International Journal of Food Properties, 23*(1), 1347–1360. https://doi.org/10.1080/10942912.2020.1797785

Soukoulis, C., & Tzia, C. (2008). Impact of the acidification process, hydrocolloids and protein fortifiers on the physical and sensory properties of frozen yogurt. *International Journal of Dairy Technology, 61*(2), 170–177. https://doi.org/10.1111/j.1471-0307.2008.00385.x

Sun, N.-X., Liang, Y., Yu, B., Tan, C.-P., & Cui, B. (2016). Interaction of starch and casein. *Food Hydrocolloids, 60*, 572–579. https://doi.org/10.1016/j.foodhyd.2016.04.029

Svensson, O., Kurut, A., & Skep, M. J. F. H. (2014). Adsorption of β-casein to hydrophilic silica surfaces. Effect of pH and electrolyte. *Food Hydrocolloids, 36*, 332–338. https://doi.org/10.1016/j.foodhyd.2013.09.006

Szymańska, I., Żbikowska, A., Kowalska, M., & Golec, K. (2021). Application of Oleogel and Conventional Fats for Ultrasound-assisted Obtaining of Vegan Creams. *Journal of Oleo Science, 70*(10), 1495–1507. https://doi.org/10.5650/jos.ess21126

Tan, J. (2019). Structuring Semisolid Foods. In H. S. Joyner (Ed.), *Rheology of Semisolid Foods* (pp. 167–201). Cham: Springer International Publishing.

Tromp, R. H., de Kruif, C. G., van Eijk, M., & Rolin, C. (2004). On the mechanism of stabilisation of acidified milk drinks by pectin. *Food Hydrocolloids, 18*(4), 565–572. https://doi.org/10.1016/j.foodhyd.2003.09.005

Velásquez-Cock, J., Serpa, A., Vélez, L., Gañán, P., Gómez Hoyos, C., Castro, C., & Zuluaga, R. (2019). Influence of cellulose nanofibrils on the structural elements of ice cream. *Food Hydrocolloids, 87*, 204–213. https://doi.org/10.1016/j.foodhyd.2018.07.035

Vithanage, C. J., Mishra, V. K., Vasiljevic, T., & Shah, N. P. (2008). Use of β-glucan in development of low-fat Mozzarella cheese. *Milchwissenschaft, 63*(4), 420–423. https://doi.org/http://hdl.handle.net/10722/144386.

Wang, F., Tong, Q., Luo, J., Xu, Y., & Ren, F. (2016). Effect of carrageenan on physicochemical and functional properties of low-fat colby cheese. *Journal of Food Science, 81*(8), E1949–E1955. https://doi.org/10.1111/1750-3841.13369

Wolfer, T. L., Acevedo, N. C., Prusa, K. J., Sebranek, J. G., & Tarté, R. (2018). Replacement of pork fat in frankfurter-type sausages by soybean oil oleogels structured with rice bran wax. *Meat Science, 145*, 352–362. https://doi.org/10.1016/j.meatsci.2018.07.012

Wusigale, Liang, L., & Luo, Y. (2020). Casein and pectin: Structures, interactions, and applications. *Trends in Food Science & Technology, 97*, 391–403. https://doi.org/10.1016/j.tifs.2020.01.027

Ye, Z., Xu, Y.-J., & Liu, Y. (2021). Influences of dietary oils and fats, and the accompanied minor content of components on the gut microbiota and gut inflammation: A review. *Trends in Food Science & Technology, 113*, 255–276. https://doi.org/10.1016/j.tifs.2021.05.001

Yousefi, M., & Jafari, S. M. (2019). Recent advances in application of different hydrocolloids in dairy products to improve their techno-functional properties. *Trends in Food Science & Technology, 88*, 468–483. https://doi.org/10.1016/j.tifs.2019.04.015

Zhang, H., Chen, J., Li, J., Wei, C., Ye, X., Shi, J., & Chen, S. (2018). Pectin from Citrus Canning Wastewater as Potential Fat Replacer in Ice Cream. *Molecules, 23*(4), 925. https://doi.org/10.3390/molecules23040925

Zhao, Q., Zhao, M., Li, J., Yang, B., Su, G., Cui, C., & Jiang, Y. (2009). Effect of hydroxypropyl methylcellulose on the textural and whipping properties of whipped cream. *Food Hydrocolloids, 23*(8), 2168–2173. https://doi.org/10.1016/j.foodhyd.2009.04.007

Zhao, Q., Zhao, M., Yang, B., & Cui, C. (2009). Effect of xanthan gum on the physical properties and textural characteristics of whipped cream. *Food Chemistry, 116*(3), 624–628. https://doi.org/10.1016/j.foodchem.2009.02.079

Zhuang, X., Gaudino, N., Clark, S., & Acevedo, N. C. (2021). Novel lecithin-based oleogels and oleogel emulsions delay lipid oxidation and extend probiotic bacteria survival. *LWT, 136*, Article 110353. https://doi.org/10.1016/j.lwt.2020.110353