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Potential for Microalgae as a Superfood in Fermented Dairy Products: A Review

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ABSTRACT

The increasing global population has pressured global food security, particularly regarding protein supply. Microalgae, with their high protein content, have garnered significant attention as a potential substitute for increasingly expensive animal-based proteins. Their incorporation into foods and beverages presents a promising strategy to address hunger and malnutrition. In this context, fortifying fermented dairy products such as yoghurt, and cheese with microalgae offers an innovative approach to developing value-added products that combine animal-based proteins with plant-based ingredients rich in protein and bioactive compounds. This review explores the effects of incorporating microalgal and their derivatives on the physicochemical, colorimetric, and antioxidant properties, texture, rheology, sensory profile, and viability of starter cultures and probiotics in yoghurt, and cheese. This literature review aims to contribute to a better understanding of the potential of microalgae as a unique food ingredient in the development of sustainable products and their beneficial health effects.

Keywords*: Fermented Dairy; Functional Food; Microalgae*

INTRODUCTION

One of the Sustainable Development Goals that has garnered global and national attention is providing nutrient-rich food to eradicate hunger, a pervasive social issue worldwide (UNICEF, 2021). The burgeoning global population poses a significant challenge to global food security, particularly regarding protein availability. The Dietary Guidelines for Americans, 2020–2025 explains that protein from both animal and plant-based contribute to nutrient intake, nutrient adequacy, and healthy diet quality. Dietary protein sources that are commonly consumed often play a significant role in providing essential nutrients, including calcium, vitamin D, potassium, dietary fiber, iron, and folate (Phillips et al., 2015). Dietary proteins are also essential for growth, weight management, and promoting satiety (Johnson et al., 2009), as well as for supporting metabolic and renal functions (Rodriguez, 2015). They also play a crucial role in preventing muscle loss, managing sarcopenia during healthy ageing, and maintaining bone health (de la O et al., 2023). Therefore, adequate protein intake should be promoted to achieve the required micronutrient intake.

Researchers have studied the development of new plant-based proteins in recent years. They have found that sources that contain micronutrients are considered to provide a variety of food products for adequate protein intake. Microalgae have emerged as a promising alternative protein-based source (Arashiro et al., 2020; Çelekli et al., 2024). While there are approximately 10 million identified microalgae species, only 50 species, such as *Arthrospira (Spirulin*a), *Chlorella, Porphyry, Nannochloropsis, Haematococcaceae,* and *Dunaliella,* have been studied for biotechnology (Koyande et al., 2019; Pina-Pérez et al., 2019). Microalgal biomass predominantly comprises proteins and carbohydrates, often constituting more than 50% of its dry weight (Çelekli et al., 2024). Furthermore, microalgae are rich in bioactive

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compounds like essential amino acids, sulfated polysaccharides, enzymes, fiber, carotenoids, vitamins, and minerals (Caporgno & Mathys, 2018). These bioactive compounds have antibacterial, antiviral, and anti-inflammatory properties (Hernández-Urcera et al., 2024). Other studies have demonstrated the anti-inflammatory, antioxidant, and antitumor activities of microalgal carotenoids (Avila-Roman et al., 2021; Caporgno & Mathys, 2018; Hernández-Urcera et al., 2024).

The fortification of food with microalgae biomass has become increasingly common. One promising application is the fortification of fermented dairy products, which have a fresh flavor and acid aroma from carbonyl compounds (Ferreira de Oliveira & Bragotto, 2022). They are widely recognized as functional foods with high consumer acceptance and regular consumption among diet-conscious individuals (Beheshtipour et al., 2012). Moreover, fermented dairy offer enhanced nutrient bioavailability (Fernandez et al., 2017) and contain abundant bioactive components such as free amino acids, bioactive peptides (Terzioğlu & Bakirci, 2023), and linoleate, oleate, and stearate acids, as well as exopolysaccharides (Fernandez et al., 2017). Moreover, the combination of fermented milk and microalgae is considered something very promising in the future. Because it provides more benefits, such as it can increase nutritional components, cell growth rate, viability during storage, and improving the texture of fermented milk. Beheshtipour et al. (2012) reported that cell growth of the probiotic mixtures of *L. acidophilus LA*-5 and *B. lactis BB-12* in yoghurts with microalgae addition (up to 1%) was significantly greater than that in the control. Luwidharto et al., (2022) showed that 0.3% *S. platensis* can accomplish the viscosity and water-holding capacity of the fermented milk after 24 h of fermentation. Their research explained that bioactive peptides and pigments (such as carotenoids, phycocyanins, and chlorophyll) of *S. platensis* contribute to increase the antioxidants in fermented milk (Barkallah et al., 2017; Luwidharto et al., 2022).

The incorporation of microalgae into fermented dairy products presents a significant opportunity to address nutritional deficiencies on a global scale and new plant-based of protein source. This review examines existing research on the addition of microalgae to various fermented dairy products. This literature review investigated the microalgae effect on fermented dairy products' nutritional, microbiological, physicochemical, and quality properties.

METHODS

A literature review search was conducted using Science Direct, Springer, Nature, Google Scholar, and NCBI (PubMed) electronic databases. The subject search terms used alone or in combination included "microalgae, type of microalgae, fermented dairy products. yoghurt, cheese, and functional compounds”. The research was conducted for 2 months, starting from August-October. The majority of sources consulted were published from 2019 up to 2024. The inclusion criteria for the selected literature were based on credibility, validity, relevance, and timeliness. The research collected data for 2 months, starting from August to October. The inclusion criteria for the selected literature were based on credibility, validity, relevance, and timeliness. The research was conducted for 2 months, starting from August-October.

MICROALGAE AND THEIR VALUABLE METABOLITES

Microalgae, microscopic organisms in various aquatic environments worldwide, have become a significant focus in nutritional and biomedical research. While most microalgae are eukaryotic, specific species such as *Arthrospira (Spirulina), Chlorella, Haematococcaceae,*

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and *Dunaliella* have been studied for biotechnological applications (Figueroa-torres et al., 2020; Koyande et al., 2019). Microalgal biomass is rich in macronutrients which have proteins, lipids, and carbohydrates, with protein content often exceeding 50% of dry weight. Notably, these proteins are highly bioavailable. Table 1. provides a comparative analysis of macronutrient composition in various microalgal species.

Table 1. Macronutrient Composition of Microalgae Biomass (dry weight)

Microalgae	Protein (dw)	Carbohydrate (dw)	Lipid (dw)	References
Chlorella vulgaris	51—58%	12—17%	14—22%	[(Çelekli et al., 2024; Figueroa-torres et al., 2020; Hosseinkhani et al., 2022)]
Spirulina platensis	50—70%	13—25%	9—14%	[(El-Moataaz et al., 2019; Figueroa-torres et al., 2020; Hosseinkhani et al., 2022; Koru, 2012)]
Dunaliella salina	38—57%	4—6%	7—32%	[(Bashir et al., 2016; Becker, 2007; Figueroa-torres et al., 2020)]
Nannochloropsis gaditana	18—50%	10—31%	10—33%	[(Figueroa-torres et al., 2020; Safi et al., 2017)]

Microalgae produce a variety of bioactive metabolites through different metabolic pathways, and these metabolites have a range of biological activities that can be useful in diverse applications, from medicine to food production (De Morais et al., 2015). Microalgae produce two main types of metabolites: Primary Metabolites and Secondary Metabolites. The primary metabolites for the algae's growth, reproduction, and basic metabolic functions, such as Lipids (Fatty acids and triacylglycerols (TAGs)), proteins (Essential for cell structure and function), Carbohydrates (Sugars and starches that store energy), and amino acids (Building blocks for proteins and enzymes). Secondary Metabolites result not directly involved in growth or reproduction but often serve in the algae's defense mechanisms, signaling, or interactions with the environment such as pigments (Chlorophylls, carotenoids, and phycobiliproteins), antioxidants (polyphenols), Bioactive compounds, (antimicrobial peptides, antitumor substances, and anti-inflammatory compounds) (Beheshtipour et al., 2013).

Microalgae have a various functional compound, including essential amino acids, pigments, free fatty acids, sulfated polysaccharides, antioxidants, and vitamins (Caporgno & Mathys, 2018; Chen et al., 2022; Hosseinkhani et al., 2022). The amino acid profile of microalgae is comparable to animal-based proteins like eggs and meat, as well as plant-based proteins such as soy (Çelekli et al., 2024). Certain amino acids can form bioactive peptides that potentially prevent cardiovascular diseases (CVD) (Hosseinkhani et al., 2022). For instance, peptides derived from *Spirulina platensis* and *Chlorella vulgaris* exhibit pronounced angiotensin-converting enzyme (ACE) inhibitory effects, suggesting antihypertensive properties (Suetsuna & Chen, 2001). Additionally, enzymatic hydrolysis of microalgal proteins has yielded bioactive peptides with therapeutic potential against oxidative stress (Maulida Safitri et al., 2017). Microalgal pigments, categorized into chlorophyll, carotenoids (carotene and xanthophyll), and phycobiliproteins like phycocyanin, possess potent antioxidant activities tersebut (Beheshtipour et al., 2013; Hosseinkhani et al., 2022; Muhaemin et al., 2010).

Spirulina platensis, as a superfood, because of rich in protein, linoleic acid, (19–26%),

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gamma-linoleic (16–25%), oleic (3–8%), dan palmitic acids (34–42%), vitamins (provitamin A, vitamin C, vitamin E), phenolic compounds, minerals, and pigments (Bashir et al., 2016; Beheshtipour et al., 2013; Ferreira de Oliveira & Bragotto, 2022; Gün et al., 2022). Its high polyunsaturated fatty acid (PUFA) content, constituting 42–45% of total fatty acids, is particularly noteworthy (Matos et al., 2017). Given its abundant nutrient profile, *S. platensis* finds applications in various products, including facial masks, dietary supplements, and animal feed (Koyande et al., 2019).

Similarly, *C. vulgaris* biomass is widely used in health supplements and fish feed (K. Rani et al., 2018). Its protein content often surpasses meat and eggs. The amino acid profile of *C. vulgaris* is superior to soy, especially in terms of essential amino acids like lysine, leucine, isoleucine, threonine, methionine, valine, and tryptophan (Table 2.) (Çelekli et al., 2024). Under optimal conditions, *C. vulgaris* can accumulate up to 22% lipids, comprising glycolipids, phospholipids, and free fatty acids (Beheshtipour et al., 2013). Other functional components of *C. vulgaris* include β 1-3 glucan, a vital polysaccharide (Zebib & Merah, 2014), dietary fiber, chlorophyll, and various vitamins and minerals (Çelekli et al., 2024).

Table 2. Composition of Essential Amino Acids (g/100 g) Microalgal Sources (dry weight).

Amino Acids	***Spirulina sp.***	***Chlorella* sp.**	***Dunaliella* sp.**	**Soy Bean**
Lysine	4,6–4,8	8,4–8,9	2,4–2,7	6,4
Leucine	8,0–9,8	8,8–9,2	3,9–5,7	7,7
Isoleucine	6,0–6,7	3,8–6,7	1,9–2,8	5,3
Threonine	4,6–6,2	4,7–4,8	1,5–2,8	4,0
Methionine	4,6–6,2	2,2	0,8–1,0	1,3
Valine	6,5–7,1	5,5–6,1	2,0–2,9	5,3
Tryptophan	5,3	2,1	0,7–1,4	1,4
Reference	[(El-Moataaz et al., 2019; Figueroa-torres et al., 2020; Hosseinkhani et al., 2022; Koru, 2012)]	(Çelekli et al., 2024)	[(Bashir et al., 2016; Becker, 2007; Figueroa-torres et al., 2020)]	(Becker, 2007)

Dunaliella salina is renowned for its high β-carotene content, reaching up to 14% of dry weight, making it a valuable source of vitamin A. β-carotene is widely used as an antioxidant, natural pigment in products like margarine and as a pigment in shrimp aquaculture (Borowitzka, 2018). Additionally, *D. salina* contains essential fatty acids such as stearic acid, methyl palmitate, ethyl α-linolenate, stearic acid, and pentadecanoic acid, which exhibit antitumor properties (Silva et al., 2021). Based on the research that has been done, all types of microalgae have excellent nutrition and are proven to provide good effects on body health. This indicates the potential for all the microalgae to be developed as a high-value food product.

FORTIFICATION OF MICROALGAL BIOMASS ON YOGHURT DERIVATIVES

According to Codex Alimentarius internationally recognized standards, yoghurt is a fermented milk utilizing specific starter cultures, such as *Lactobacillus bulgaricus* and *Streptococcus thermophilus* during fermentation. Yoghurt is rich in diverse nutrients and offers various health benefits (Fernandez et al., 2017; Hartono et al., 2024). Consequently, it

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is widely consumed globally and known by various names such as ayran, dahi, laban, coalhada, and matsoni (Bamnya, 2024). Studies investigating the fortification of yoghurt with microalgal biomass have significantly affected the product's nutritional composition, functional compounds, starter culture growth, and physicochemical properties. While some studies incorporated microalgal biomass before fermentation, others added it post-fermentation (Hernández et al., 2022).

a. Changes in Functional and Microbiological Component

Fortification with *S. platensis* biomass led to increased levels of macronutrients, including proteins, lipids, and carbohydrates. This is attributed to the high protein content of *S. platensis*, which can reach up to 70% in some studies (Hosseinkhani et al., 2022; Koru, 2012). Similarly, the fortification of ayran with *S. platensis* resulted in a significant increase in protein content (approximately 5%) (Çelekli et al., 2019). Moreover, microalgal fortification contributed to the enrichment of various bioactive compounds with antioxidant properties, such as β-carotene, phycocyanin, chlorophyll, astaxanthin, and lutein (Barkallah et al., 2017; Beheshtipour et al., 2013; Gauthier et al., 2020). The yoghurt exhibits antioxidant properties due to the formation of bioactive peptides during fermentation. Combining these peptides with the amino acids, carotenoids, and other compounds present in microalgae further enhanced the antioxidant capacity of the fortified yoghurt (Beheshtipour et al., 2013; Terzioğlu & Bakirci, 2023). Luwidharto et al. (2022) reported that adding up to 0.6% *S. platenis* biomass to probiotic fermented milk increased antioxidant activity by 30% after fermentation. Other studies have also shown that *S. platensis* supplementation at concentrations of 0,25, 0,5, and 1% significantly enhanced antioxidant activity by up to 111% (Khaledabad et al., 2020; Atallah et al., 2020; Barkallah et al., 2017).

The biomass of *S. platensis* includes amino acids (from milk and microalgae, promoting cell growth and acid production in yoghurt. Luwidharto et al., (2022) showed that the culture of *Lactobacillus* needs arginine, glutamic acid, leucine, valine and cysteine or methionine, while *S. thermophilus* needs histidine and cysteine or methionine. That component is required by the cell growth of lactic acid bacteria during fermentation. In addition to amino acids, essential vitamins, minerals, adenine, hypoxanthine, and linolenic acid in Spirulina also contributed to increased cell growth (Beheshtipour et al., 2013). Studies by Khaledabad et al. (2020) and Luwidharto et al. (2022) demonstrated that the addition of up to 0.6% *S. platensis* to yoghurt resulted in higher cell counts (8 log CFU/mL) compared to the control (6 log CFU/mL), leading to increased lactic acid production during fermentation. Beheshtipour et al. (2012) reported that adding *C. vulgaris* and *S. platensis* biomass helped maintain the viability of probiotic cells (*L. acidophilus* and *B. lactis BB-12*) at 8 log CFU/mL after 21 days of storage.

b. Changes in Physical Quality

The physical characteristics of yoghurt are significantly influenced by adding microalgae and are crucial determinants of product quality. Pigments inherent in microalgae, including chlorophyll, carotene, and phycocyanin, impart a distinctive greenish-blue hue to yoghurt, which undergoes alterations during fermentation (Pan-utai & Iamtham, 2019). Luwidharto et al. (2022) observed a noticeable color shift from a faded greenish-blue to a light green hue in yoghurt fortified with 0,3% *S. platensis* after 24 hours of fermentation (Figure 1.). Similarly, Barkallah et al. (2017) and Pan-utai & Iamtham, (2019) reported a lighter green coloration in

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yoghurt fortified with *S. platensis* biomass compared to control samples. However, Martelli et al. (2020) found a more stable color in yoghurt fortified with *S. platensis* after 24 h of fermentation at 37°C. These color variations are primarily attributed to the degradation of chlorophyll and phycocyanin during fermentation. Phycocyanin, in particular, exhibits reduced stability at pH levels ranging from 3 to 4 and temperatures exceeding 45°C (Wu et al., 2016). Decreasing pH and increasing temperature disrupt protein bonds, releasing pigments bound to proteins through hydrolysis by enzymes produced by lactic acid bacteria (de Marco Castro et al., 2019).

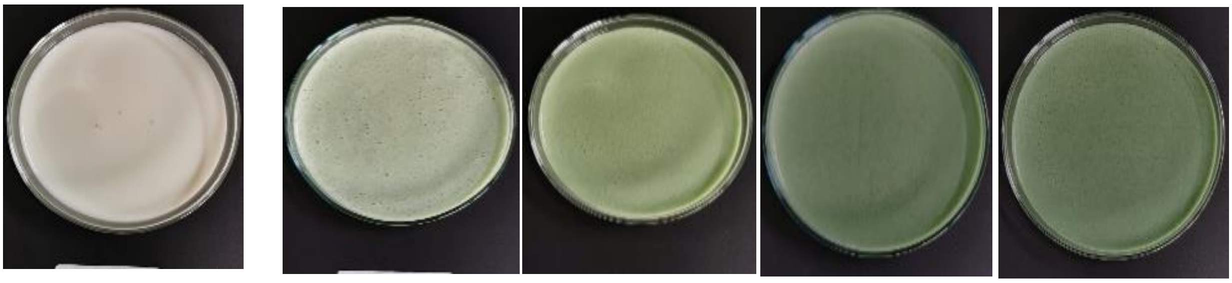

Figure 1. Yoghurt Samples: (A) 0,15% (B) 0,3% (C) 0,45% (D) 0,6% *S. platensis* Containing Samples (Luwidharto et al., 2022)

Beyond color, the addition of microalgae also impacts syneresis, water-holding capacity (WHC), and viscosity of yoghurt. These changes are attributed to the forming of a three-dimensional network composed of casein, denatured whey proteins, and fat globules (R. Rani & Singh, 2012). Fortification with microalgal biomass has decreased syneresis and increased WHC in yoghurt. Bchir et al. (2019) observed a reduction in syneresis with increasing concentrations of *S. platensis* in yoghurt. Pan-Utai et al. (2020) reported a WHC of 55% after 4 hours of fermentation in yoghurt fortified with 0,3% dried *S. platensis*. Atallah et al. (2020) found that adding 1% *S. platensis* powder to yoghurt increased WHC to 56% after fermentation. Moreover, microalgal fortification significantly enhanced viscosity. Bchir et al. (2019) reported a higher viscosity in samples fortified with 0.5% *S. platensis* than the control. These findings are supported by other studies, including those by (Agustini et al., 2017) and Luwidharto et al. (2022), which demonstrated that microalgae can improve the viscosity of yoghurt. The improved physical properties of yoghurt fortified with microalgae are attributed to microalgae's protein and exopolysaccharide content, which act as gelling agents, stabilizers, and emulsifiers. The interaction of microalgal proteins with water is crucial for the formation and stability of the gel structure (Bashir et al., 2016; Ursu et al., 2014).

Research on microalgae fortification in fermented milk products has demonstrated significant benefits. The addition of microalgae enhances the nutritional and bioactive content of fermented milk products, minimizes texture damage, improves cell viability and acid production, and boosts antioxidant activity. However, the development of these products is still hindered by the off-flavors produced by microalgae. To date, there has been no commercial use of fermented milk products containing added microalgae.

FORTIFICATION OF MICROALGAL BIOMASS ON CHEESE DERIVATIVES

Cheese, a versatile dairy product, has been consumed globally for centuries. This review focuses on cheeses produced using starter cultures during fermentation, such as soft

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cheese, feta-type cheese, quark cheese, and cream cheese. Recent research has explored the potential of enhancing cheese's nutritional, functional, microbiological, physicochemical, and quality product properties by adding microalgal biomass.'

a. Changes in Macro-nutrient and Functional Component

The high protein content of microalgae significantly impacts the nutritional profile of cheese. Fortification with microalgae results in a higher protein content compared to control samples, ranging from 12-14% dry weight (Darwish, 2017; Golmakani, 2018; Katsaros, 2021). Meanwhile, carbohydrates change depending on the specific cheese product. (Katsaros, 2021) found no significant impact on the carbohydrate content of cream cheese; quark cheese's carbohydrate content increased by up to 6% with the addition of 4% *C. vulgaris*. The lipid content and micronutrients in microalgae contribute to the functional properties of cheese. For instance, feta-type cheese fortified with *S. platensis* exhibited higher levels of palmitic acid, oleic acid, and myristic acid, as well as minerals such as phosphorus, potassium, manganese, copper, and zinc (Golmakani, 2018). (Darwish, 2017) reported a significant increase in iron content (up to 2 mg/100g) in kareish cheese fortified with 1.5% S. platensis biomass.

Microalgae are rich in phenolic compounds and flavonoids, which possess various pharmacological effects, including antioxidant activity (Hernández et al., 2022). Falcão et al., (2023) reported higher total phenolic content in quark cheese fortified with 2 and 4% *C. vulgaris*, reaching 4 mg/g, while cream cheese showed no significant difference.Golmakani, (2018) observed a significant increase in total phenolic content in feta-type cheese fortified with *S. platensis*. The antioxidant activity of cheese was also enhanced by microalgae fortification. Darwish, (2017) demonstrated that the antioxidant capacity of kareish cheese increased with increasing concentrations of *S. platensis*, as evidenced by higher levels of total phenolic content, total flavonoids, β-carotene, and DPPH. The antioxidant properties of microalgae-fortified cheese increase during the fermentation process. Phenolic compounds are crucial antioxidants because they stabilize radicals by donating hydrogen atoms or electrons. Niccolai et al. (2020) explained the total phenolic content (TPC) increased during the first 36 hours of fermentation, attributed to the release of phenolic compounds through bacterial enzymatic hydrolysis of the *Spirulina* cell walls. Phycocyanin content also contributes to changed antioxidant profiles. de Marco Castro et al., (2019) showed the C-phycocyanin content in fermented *S. platensis* increased by 32.64%. It reflects a release of this protein-bound pigment via enzyme hydrolysis during the fermentation process. Hydrolysis of protein bonds produced bioactive peptides that acted as antioxidants Niccolai et al., (2020). In addition, other bioactive compound such as tocopherol, chlorophyll, and carotenoids in *Spirulina platensis*, and chlorophyll, lutein, and phenolic compounds in *C. vulgaris* might contribute to increased antioxidant activity of cheese fermentation (Cha et al., 2010).

b. Changes in Microbiological and Physicochemical Properties

Starter cultures significantly influencing the final product's physicochemical and sensory attributes (Fernandez et al., 2017). The addition of microalgae to cheese has demonstrated varying effects on the growth of these starter cultures. Studies have shown that the addition of microalgae can either stimulate or inhibit the growth of specific bacterial groups. For instance, Golmakani, (2018) reported a significant increase in *Lactobacillus casei* counts in

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feta-type cheese fortified with 0,5% and 1,0% *S. platensis*. Similarly, Katsaros, (2021) observed enhanced viability of *Lactobacilli* in Traditional Greek Soft Cheese when fortified with *S. platensis*. However, increasing the *S. platensis* concentrations did not significantly affect the viability of *Lactococci* cells after 7 days of storage. According to Luwidharto et al. (2022), the specific nutrient requirements of different starter cultures can influence their ability to utilize the available substrates. Thus, the impact of microalgae on starter culture growth is likely dependent on the interplay between the microalga species, the cheese matrix, and the specific nutrient needs of the starter culture.

Naturally, lactic acid bacteria (LAB) utilize lactose and other sugars for growth and metabolism, producing acids. Golmakani, (2018) reported that the fortification of feta-type cheese with microalgae resulted in higher titratable acidity (TA) compared to the control, both initially (4,40–9,45%) and after 60 days of storage (3,35–10,05%). TA values increased with increasing concentrations of *Spirulina platensis*. The study also indicated that control cheeses had higher pH values compared to cheeses supplemented with *S. platensis* up to 15 days of storage. (Beheshtipour et al., 2013) demonstrated a decrease in pH from 5,42 to 5,39 in analog cheese fortified with *Chlorella vulgaris* at 1, 2, and 3% w/w, compared to the control (pH 5,80).

c. Changes in Physical Quality

Texture is a quality attribute in cheese. The fortification of microalgae can significantly influence the textural properties of cheese. Studies have shown varying effects of microalgae on cheese texture, likely due to differences in cheese type, microalgae species, and concentration. Falcão et al. (2023) explained that the decreasing firmness value leads to a softer texture of quark cheese and cream cheese with *C. vulgaris* compared to control. However, the difference in *C. vulgaris* concentrations did not result in a significant difference compared to the control. Mohamed et al. (2013) observed increased firmness in analog cheese fortified with *C. vulgaris*. Golmakani, (2018) found that *S. platensis* reduced the hardness of feta-type cheese, while Darwish, (2017) reported increased hardness, cohesiveness, gumminess, and chewiness in kareish cheese with increasing *S. platensis* concentrations. The ability of microalgal proteins and polysaccharides to bind water and maintain the casein gel network is often cited as a mechanism for altering cheese texture. For instance, the softer texture observed in some studies may be due to the microalgae's ability to retain moisture, disrupting the cheese's structure.

In addition to affecting texture, microalgae also influence the color of cheese (Figure 2.). The presence of pigments such as chlorophyll a and b and carotenoids in microalgae can impart a greenish hue to cheese. Falcão et al. (2023) and Darwish, (2017) observed a decrease in lightness (L*) and redness (a*) values and an increase in yellowness (b*) values in cheese fortified with *S. platensis*, indicating a shift towards a greener color.

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(A) (B)

Figure 2. Cheese Enriched with Microalgae (A) Fresh Cheese (B) Fresh Cheese type-Galotyri (Katsaros, 2021)

Currently, most of the use of microalgae types in cheese products are only Spirulina platensis and Chlorella vulgaris. In fact, microalgae have add-value products that can be used to improve the quality of cheese physically, microbiologically, and nutritionally. In addition to the 2 types of microalgae, there are *Dunaliella* and other types that can be explored into cheese products and their derivatives.

Conclusion

Fortification of Microalgae has emerged as a promising strategy to enhance fermented dairy products' nutritional and functional properties. Studies have consistently demonstrated that incorporating microalgae into these products can increase nutrient content, improve viscosity and water-holding capacity, and enhance starter culture growth. The optimal concentration of microalgae is crucial to maximize these benefits. While *Spirulina platensis* has been the primary focus of research, other microalgae species, such as *Chlorella vulgaris*, *Dunaliella salina, etc* offer the potential for further exploration, evaluate organoleptic properties and consumer acceptance, and develop scalable production processes.

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