Review Paper

Technological aspects, health benefits, and sensory properties of probiotic cheese

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Abstract
Probiotics are live microorganisms, which provide health benefits when they are presented in adequate amounts. Probiotics have been incorporated recently in many dairy products, such as fermented beverages, yogurt, and cheese. Cheese is a suitable carrier for the probiotics into the human intestine. The objectives of this work are to highlight and review the importance of using cheese as delivery for probiotics and its high potential to increase the viability of probiotics. Secondly, this review presents the physiochemical characteristics of probiotic cheese and its sensory characteristics as compared to the nonprobiotic cheese. Finally, this work emphasizes the health benefits of integrated probiotics in cheese.

Keywords Probiotics · Cheese · Sensory characteristics · Human health · Cheese quality · Cheese technology

1 Introduction

Probiotics are defined as living microorganisms, which can afford health benefits when they exist in adequate amounts. Probiotics have many benefits, such as protecting the human or hosts from many pathogens, enhancing the immune system, relieving lactose intolerance, and decreasing the cholesterol [1, 2]. Many studies are interested in incorporating the probiotics in several dairy products to increase the nutritional value. Several strains of bifidobacteria and lactobacilli are commonly employed in the manufacturing of probiotic foods [3]. Probiotics have been incorporated in many dairy products, such as yogurt, cheese, and other fermented milk.

The count of viable probiotics in the different products at the time of consumption should range from 5.0 to 7.0 log cfu/g to afford the health benefits to the human or hosts [4]. Cheese is the most effective carrier for probiotic bacteria [5] due to its buffer function in the acidic conditions during digestion in the gastrointestinal tract and its protective function in the stomach [6]. Many varieties of cheeses have been manufactured with probiotic bacteria, such as Karish cheese, Cheddar cheese, Gouda cheese, Ras cheese, Cottage cheese, and white or fresh cheeses [7–16]. The probiotic strains are selected based on the type and manufacturing conditions of cheese [5]. Thus, fresh cheese or cheese at the beginning of ripening has a high total count of lactic acid bacteria while the count of nonlactic acid bacteria increases only with increasing the ripening period [17].

Addition of probiotics in cheese should also not affect its organoleptic and texture characteristics. Some studies reported that the sensory properties of cheese were not affected by probiotics [18], however, others reported that they could slightly change the sensory properties [12, 19, 20]. The added probiotics should be beneficial to the health and should not adversely affect the flavors of the product to be successfully marketed [21].

This work aims to review and highlight the incorporation of probiotics in cheeses and their viability such as different strains of bifidobacteria and lactobacilli and how these probiotics can affect the quality and sensory characteristics of cheeses during the ripening period.

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Furthermore, the benefits of probiotics on human health are also discussed in this review.

2 Probiotic cultures in cheese

The FAO/WHO identified the probiotics as living microorganisms, which provide benefits to human health when they exist in adequate amounts. Many arguments have been found about the positive influences of probiotics to cure diseases, such as lactose intolerance [22]. Several varieties of probiotic microorganisms are well adapted in cheese manufacturing, such as enterococci, lactobacilli, and propionibacteria [23]. Also, probiotic microorganisms (such as bifidobacteria and lactobacilli) are commonly incorporated to manufacture milk, yogurt, ice cream, and desserts as probiotic dairy food products [24].

Nevertheless, the environments of these probiotic dairy food products are different from the human gut/intestine conditions, which result in deleterious impacts on the viability of probiotics microorganisms [22]. Probiotics need low temperature, low acidic conditions, low oxygen level, and high-fat content. As a result, cheese is a suitable probiotic food carrier [2].

3 Cheese as a probiotic food delivery

Probiotic foods should transfer their benefits into the consumer's body, and therefore, the inoculated probiotic bacteria in cheese should grow in the body to provide the benefits and survive the hydrochloric acid conditions and bile salts in the stomach and small intestine, respectively, during their pass to reach the gastrointestinal tract [25].

Cheeses are considered valuable transporters of probiotic microorganisms instead of fermented milk and yogurts. Cheese has certain potential advantages, such as working as a buffer to adopt with the acid in the gastrointestinal tract which increases the pH, and this, in turn, makes a suitable condition for the probiotic bacteria [5]. Additionally, the thickness of cheese and its high percentage of fat could protect the probiotic microorganisms during consumption and ingestion [17]. The viability of *Lactobacillus casei* 334e has been studied in both yogurt and reduced-fat Cheddar cheese at the refrigerator temperature and the gastric conditions at pH 2 [26]. This study concluded that the viability of these bacteria was high in both products (7.0 log cfu/g) [26]. In terms of acidic tolerance, the viable cells decreased after 120 min to 4.0 log cfu/g in low-fat Cheddar cheese, while the viable cells decreased to 1.0 log cfu/g in yogurt after 120 min in acidic conditions.

It has been showed that requeijão cheese (Portuguese whey cheese) has similar conditions as well as in the gastrointestinal tract. However, the viability of the following probiotics: three strains, two strains, one strain, and one strain of *Bifidobacterium animalis*, *Lactobacillus acidophilus*, *Lactobacillus paracasei*, and *Lactobacillus brevis*, respectively, reduced when they passed through a pH 2.5–3.0 of acidic hydrochloric solution, concentration of a 1000 units per mL of pepsin at 37 °C, and a 0.3 gm per 100 of bile salts solution [27]. The Fresco cheese (Argentinean cheese) had similar outputs. Thus, a different combination of *L. acidophilus*, *Bifidobacterium* spp., and *L. casei* (two strains, one strain, and two strains, respectively) was examined as probiotic adjunct cultures for manufacturing of fresco cheese. The viability of these probiotics was studied in acidic environmental conditions at pH = 2 and pH = 3. All probiotic cultures were viable even for up to 3 h. The probiotic culture of *L. casei* Cl had a higher resistant compared to other cultures at pH = 3, which showed two log cycles less. At pH 2, *L. casei* Cl also had high resistance, while *Bifidobacterium bifidum* B4 was susceptible [9].

4 Cheese as probiotic food matrix

As mentioned previously, cheese is considered a suitable delivery for probiotics to the human intestine compared to the fermented milks because of the chemical composition and physical properties of cheese (e.g., high pH, low acidity, high fat content, high buffering ability, low oxygen, and the dense matrix or thickness of cheese texture) that could increase the viability of probiotic microorganisms. Probiotic bacteria have been used in manufacturing different varieties of cheese around the world, namely Ras or Roumy cheese [7], Mascarpone cheese [28], Minas fresh cheese [29, 30], fresh cheese [31], soft cheese [32], fresh cream cheese with inulin as supplement [33], Festivo cheese [19], Crescenza cheese [20], Fresco cheese [9], cottage cheese [15], *Petit-Suisse* cheese [34], Pategrás cheese [35, 36], Tallaga cheese [37], Iranian-type white cheese [38], Karish cheese [14], Cremoso cheese [36], Gouda cheese [16], probiotic goat's cheese [39, 40], Canestrato Pugliese hard cheese [3], Turkish white cheese [10], Cheddar cheese [13, 26, 41, 42], Turkish-type Beyaz cheese [43], white-brined cheese [44], Kasar cheese [45], and cheese dips [46]. It has been reported that many probiotics (such as *B. animalis* ssp. *lactis*, *Bifidobacterium longum*, *B. bifidum*, *Bifidobacterium infantis*, *L. acidophilus*, *L. casei*, *L. paracasei*, *Lactobacillus plantarum*, *Lactobacillus rhamnosus*, *Lactobacillus gasseri*, and *Propionibacterium freudenreichii* ssp. *Shermanii*) have been incorporated successfully in several varieties of cheeses [1].

The minimum level of viable probiotics should be ≥ 10^6 cfu/g at the consumption time to provide their health benefits. The probiotics incorporated during cheesemaking should be adequate to survive during cheese production and have the least amount of viable probiotics before consuming the cheese. Therefore, the probiotic strains should be selected based on the cheese type and conditions of manufacturing. A high count of starter lactic acid bacteria was found immediately after probiotic cheese manufacturing (fresh cheese), and non-starter lactic acid bacteria increased during the storage [17]. As a result, maintaining viable probiotics in aged cheese is complicated. However, the viable probiotic bacteria have been found in several varieties of cheese by the end of storage. It has confirmed that the viability of probiotic bacteria had a small shrink during storage [1]. At the end of the aging or maturation period of different cheeses, the viable probiotic counts in several studies were > 10^6 cfu/g [1]. All of these data have been confirmed that cheese is an ideal carrier of probiotics until consumption.

It is significant for the probiotics to be alive in products until consumption; however, the viability of probiotics after their passage to the gastrointestinal tract environment is also important. The potentiality to deliver the probiotics into the intestine as food matrices is high compared to the liquid carrier. In vivo experiments have been designed to examine the viability of probiotics in a simulator of the gastrointestinal environment. However, few studies have been done on the probiotic survival in cheeses under the gastrointestinal tract environment. The simulated gastrointestinal tract conditions were examined by using *B. bifidum* and *L. casei* in different cheeses, such as Fresco cheese (fresh-type cheese), Cheddar cheese (hard cheese), and Minas cheese (fresh-type cheese) which showed an excellent support of cheese matrix with loss of 2–3 log cycles viability [9, 26]. Other properties of probiotic cheese, such as the sensory characteristics, chemical stability, and microbiological properties, during the cheese ripening are required besides containing viable bacteria throughout processing and until consumption within the gastrointestinal tract.

5 The viability of some probiotics in cheese

The minimum count of probiotics in cheese during the marketing or consumption stage is 6.0 log cfu/g to provide their health benefits [47]. Depending on this criterion, different types of cheese seem to be a suitable carrier to deliver the probiotic with the stability of the viable counts during the ripening or storage period (Table 1).

Bifidobacteria and lactobacilli originated from the gut, which are identified as anaerobic bacteria [55]; however, their resistance to oxygen varies within strains and species [56]. Both showed low resistance under extended acidic conditions, but bifidobacteria are more affected by these conditions than lactobacilli [24]. Yogurt was manufactured by *Lactobacillus delbrueckii* subsp. *bulgaricus* and had an initial pH of 4.1–4.4, which decreased to 3.8–4.2 during storage. However, the pH of soft curd cheese, such as Camembert cheese, was below 5.0 after manufacturing, and it increased quickly to 6.8 in the cheese core and 7.5 on the rind of cheese in 35 days of ripening. The pH of semi-hard and hard cheeses after manufacturing is > 5.0 and becomes stable during the ripening period [57]. Moreover, the temperature, the longevity of ripening, the existence of nonstarter lactic acid bacteria with antagonistic activities, milk heat treatment, and added salts affect the viability of probiotics [41, 49, 54].

Different *Bifidobacterium* strains are efficiently used in cheese manufacturing without change in the process. Manufacturing of yogurt is restricted to *B. animalis* because of its resistance to the high acid content and oxygen, which is different from the bifidobacteria in human [24, 58]. However, cheese is a proper delivery for giving more options for adding *Bifidobacterium* strains in functional foods. Also, cheese provides more protection in the harsh conditions of the stomach. It has been reported that *B. bifidum*, *L. acidophilus*, and *L. casei* which are used in making Fresco cheese were viable up to 3 h at pH of 3.0/37 °C [9]. Cheddar cheese with *Enterococcus faecium* was tested in vitro, and it gave more protection to the strain compared to yogurt [59]. Furthermore, *P. freudenreichii* used in the manufacturing of Swiss-type cheese showed an increase in the resistance level of cells to acidic conditions [60]. Although cheese is a proper delivery for probiotics, increasing the viable cells could impact the quality of cheese, such as the organoleptic properties.

6 The effects of bifidobacteria and lactobacilli on the quality of cheese

The chemical composition of cheeses was not affected by the probiotic bacteria [3, 11, 49, 54]. However, it was reported that using *Bifidobacterium lactis* strain Bb-12 in the production of Cheddar cheese led to increase in the high moisture content from 38% in control to 40% due to the rapid acidification of *Bifidobacterium lactis* Bb-12 employed in making Cheddar cheese [13]. The increase in moisture content led to a plummet in the body and texture scores during the sensory test [13].

The incorporation of probiotics in cheesemaking does not primarily influence the proteolysis, which results from the activity of coagulant agents and limited impacts of plasmin [61]. Nevertheless, the proteolysis and a high amount of amino acids had detected when probiotics were incorporated in cheesemaking [7, 13, 54]. The cheese flavor, such as acid, sweet, bitter, and

Table 1 Viability of probiotics in some cheeses. Adapted from [23]

Cheese type	Ripening period/ temperature	Strains	Cell count (log cfu/g)		References
			Fresh[a]	End[b]	
Fresco cheese (soft cheese)	9 wk/4 °C	*B. longum* (two strains)	6.4–7.6	5.9–7.3	[9]
		B. bifidum (two strains)	7.7–8.7	6.9–8.6	
		Bifidobacterium sp (one strain)	7.0–7.6	6.6–7.6	
		Lb. acidophilus (two strains)	6.0–8.7	5.6–8.6	
		Lb. casei (two strains)	7.0–8.4	7.0–8.7	
Crescenza soft, rindless cheese	2 wk/4 °C	*B. bifidum*	6.0^2	8.0	[48]
		B. longum	6.0^2	7.1	
		B. infantis	6.0^2	5.2	
Minas fresh cheese	3 wk/5 °C	*Lb. acidophilus* La5	6.3	6.7	[11]
White-brined cheese	13 wk/4 °C	*B. bifidum* Bb02	9.0	7.0	[49]
		Lb. acidophilus La5	9.0	7.0	
Semi-hard goat's milk cheese	10 wk/6 °C	*B. lactis*	8.3–8.6	6.9–8.0	[50]
		Lb. acidophilus	7.8–8.5	6.8–7.5	
Semi-hard cheese	4 wk/12 °C	*Lb. acidophilus*	6.9	7.8	[51, 52]
		Lb. paracasei	7.4	9.1	
Canestrato Pugliese hard cheese	12 wk/12 °C	*B. bifidum* Bb02	7.1	6.0	[3]
		B. longum Bb46	7.0	5.0	
Cheddar cheese	24 wk/6–7 °C	*B. bifidum*	6.0	7.0	[8]
	12 wk/4 °C	*B. infantis* ATCC 27920G	6.7	6.6	[53]
	28 wk/8 °C	*B. lactis* Bb12	8.9	8.2	[13]
		B. longum BB536	6.4	5.2	
	32 wk/9–10 °C	*B. lactis* B94	8.0	7.6	[41]
		B. lactis Bb12	8.0	8.2	
		Bifidobacterium sp. DR 10	8.7	8.7	
		Lb. acidophilus L10	7.6	3.7	
		Lb. acidophilus La5	8.3	3.6	
		Lb. paracasei L26	8.4	7.4	
		Lb. casei Lc1	7.8	7.2	
		Lb. rhamnosus DR20	8.2	8.0	
	24 wk/4 °C	*Lb. acidophilus* 4962	8.3	8.3	[42, 54]
		Lb. casei 279	8.5	8.6	
		B. longum 1941	8.0	8.3	
		Lb. acidophilus L10	8.4	8.5	
		Lb. paracasei L26	8.5	8.5	
		B. lactis B94	7.5	7.5	

[a]Cell concentrations at the beginning of the ripening period

[b]Cell concentrations at the end of the ripening period

malty, resulted from the produced small peptides and amino acids in cheese and might contribute to the synthesis of other flavors which resulted in off-flavors [23].

The lipolysis also has a critical role in developing the cheese characteristics during the ripening. Due to the high lipolysis of starter cultures and some of the non-starter lactic acid bacteria, the probiotic microorganisms have no effects on the free fatty acids content in the cheese through the aging period [3].

Due to the heterofermentation in lactobacilli and bifidobacteria, several varieties of cheese which are manufactured by these species have high acetic acid content [3, 13, 54]. Through the fructose 6 phosphate shunt pathway, bifidobacteria produce acetic and lactic acid by 2:3 ratios from lactose fermentation. Some lactobacilli can produce limited amounts of acetic acid as compared to bifidobacteria [62]. The acetic acid has resulted in the typical flavor of several types of cheese, and its excessive amounts lead to the off-flavors in cheese [63].

The β-galactosidase activities of bifidobacteria could increase lactose maldigestion [64]. When bifidobacteria were used to manufacture Crescenza-, Canestrato Pugliese-, and Cheddar-like cheeses, the lactose was hydrolyzed entirely, which leads to the accumulation of small galactose [3].

It has shown already in many studies that cheese is a suitable environment for probiotic bacteria [2, 47]; however, few probiotic bacteria have been developed in cheese compared to yogurts or fermented milk. Additionally, probiotic strains should be selected carefully to maximize the viability of these bacteria during the cheese manufacturing and ripening and to reduce the changes in organoleptic characteristics. Propionibacteria, which are recently identified as probiotic bacteria [65], could be further examined as probiotic cheese, especially in Swiss-type cheeses.

7 The sensory characteristics of probiotic and nonprobiotic cheese

The probiotic cheese should provide the minimum flavor of nonprobiotic cheese. The added species and strains primarily impact the flavor and odor of cheese and their metabolic activity through manufacturing and ripening. Many studies have reported that the inoculation of probiotics in cheese manufacturing does not significantly affect the sensory properties of the final cheese compared to control. Using bifidobacteria in Cheddar cheese manufacturing did not increase the metabolic action and did not affect the cheese quality (flavor, texture, and appearance) during the 24th week of ripening period [8]. It has been reported that the incorporation of bifidobacteria in cheeses led to higher acetic acid and lactic acid contents; however, no differences in sensory properties were noticed [54]. Thus, bifidobacteria did not present any strong metabolic activity. Adding a mixture of *L. paracasei* and *Lactobacillus salivarius* in cheese has no adverse effects on the organoleptic characteristics and chemical composition compared to control cheeses [66]. Some researchers reported that probiotic bacteria had no effects on the texture and flavor of cheese [8]. It also reported that *L. acidophilus* La-5 had no significant effect on Minas fresh cheese at 5 °C through the 7 days of storage [11]. These types of cheese are acidified directly with lactic acid or by adding a mixture of *Lactococcus lactis* ssp. *lactis* and *L. lactis* ssp. *cremoris* (mesophilic lactic culture). The addition of *Lactobacillus paracasei* as coculture with *Lactobacillus salivarius* during the manufacturing of Cheddar cheese did not change the organoleptic properties as compared to control cheeses [12]. These results have been confirmed when *L. paracasei* was incorporated in Cheddar cheese [66]. Adding *L. acidophilus* La-5 in Minas fresh cheese maintains the sensory characteristics up to 14 days, and this stability increased when the probiotic was added as coculture to *Streptococcus thermophilus* [29].

Different investigations have showed that adding probiotic bacteria into cheeses decreases the flavor acceptability of cheese compared to control cheeses. The proteolytic enzymes (which are originated by lactic acid bacteria) break down the milk proteins to produce small peptides and amino acids [67, 68]. It has been found that the addition of different strains of probiotics into Cheddar cheese and Ras cheese resulted in decreasing the flavor of these cheeses [7, 54]. However, the bitterness, sour or acid taste, and vinegary taste scores are higher in cheeses made with probiotic bacteria than cheese without probiotic bacteria. The bitterness score of cheeses made with *L. casei* 279 and *L. paracasei* L26 was elevated than control cheeses [54]. Similar results (increasing the bitterness) were reported when lactobacilli were incorporated in Cheddar cheese [69]. The complex peptidases system of lactobacilli contributed to the high bitterness in Cheddar cheese. The high level of bitterness and sour flavor in Cheddar cheese was also reported when lactobacilli were incorporated in making Cheddar cheese [70]. Many of these studies confirmed that the bitterness score was only high during the first 6 mo of ripening, so the bitterness and acid tastes should be controlled to produce high-quality probiotic cheeses. Addition of *L. paracasei* ssp. *paracasei* strain CHCC 2115 in cheese resulted in weak texture, mild odor, fresh acidity, and low bitterness [71]. Incorporation of some bifidobacteria, especially bifidobacteria, in cheesemaking led to off-flavors in cheese with high acetic acid or vinegary taste [13, 54]. Three levels of *L. acidophilus* (at 0, 0.4, or 0.8 g/L of milk) were added to examine the physiochemical and sensory characteristics of Minas fresh cheese [30]. The probiotic cheese had lower scores for appearance, aroma, and texture compared to traditional or nonprobiotic cheese due to the synthesis of organic acids from microbial metabolism. Increasing the amount of added *L. acidophilus* in cheese manufacturing could affect adversely the sensory characteristics of probiotic cheese, such as appearance, aroma, taste, and texture.

It has been announced that some probiotic strains could improve cheese quality and sensory properties [29]. Addition of *Lactococcus casei* ssp. *rhamnosus* LBC 80 with *L. lactis* ssp. *lactis* (two strains) and *L. lactis* ssp. *cremoris* (one strain) improved the sensory properties and texture of reduced-fat Kefalograviera cheese after 3 and 6 mo of storage compared to the control cheese [72]. Other studies have reported that Ras cheese made from *L. delbrueckii* subsp. *bulgaricus* as coculture with *S. thermophilus* improved the flavor characteristics during 90 days of ripening [7]. The sensory properties of Arzúa-Ulloa cheeses were enhanced when bitterness was reduced in the control cheeses [73]. Five strains of *Lactobacillus* were tested individually, namely *L. casei* ssp. *casei*, *L. plantarum*, *L. casei* ssp. *Pseudoplantarum* (two strains), and *Lactobacillus casei* and with one aromatic acid starter culture *L. lactis* ssp. *lactis* or *L. lactis* ssp. *lactis* var. *diacetylactis*. The addition of *Bifidobacteria animalis* ssp. *lactis* Bb-12 led to produce cheese with stronger flavor than *Bifidobacterium longum* [74]. The high content of some peptidases that resulted from *L. lactis* ssp. *cremoris* led to improvement in the quality of cheeses [75]. Improvement in sensory properties of Cheddar cheese has been shown by using *Lactobacillus* adjuncts [76]. It has been reported that the flavor, appearance, and texture of Festivo low-fat cheese are improved by using *L. acidophilus* and *Bifidobacterium* spp. [19].

8 The health benefits of probiotic cheese

Probiotics have shown the potential to be beneficial for our health [77]. Many studies have described their health benefits on gastrointestinal infections, antimicrobial activity, improvement in lactose metabolism, reduction in serum cholesterol, immune system stimulation, antimutagenic properties, anti-carcinogenic properties, antidiarrheal properties, improvement in inflammatory bowel disease, and suppression of Helicobacter pylori infection by addition of selected strains to food products [1, 2, 78–83].

The probiotic dairy foods should provide benefits to human health and assure that food processing does not change their characteristics [25]. Consequently, the incorporated probiotic bacteria in cheese should be examined in vivo and verify whether these probiotic microorganisms could be viable during products processing until consumption. The antagonistic and symbiotic effects of mixed strains of probiotic should also be tested in multiple strains products [5]. It has been declared that the consumption and intake of probiotic cheeses provide health benefits to humans and animals. The viability and delivery of *E. faecium* Fargo 688 are high in Cheddar cheese through the storage period as compared to yogurt.

The fresh Argentinean cheese made with A9 strain of *L. acidophilus*, A12 strain of *B. bifidum* and A13 strain of *L. paracasei* after 2, 5, and 7 days of consumption led to improvement in the immune system of the mice and phagocytic action in the small intestine of peritoneal macrophages. After 5 days of ingestion, IgA^+ also increased in the large intestine. The probiotic bacteria have interacted as antigen in the small and large intestines [84]. The phagocytic cells have a critical role in infectious bacteria. It has been reported that IgA antibodies which are responsible for the humoral immunity are dominant in mucosal surfaces and protect the gut mucosa from pathogens [5].

The efficiency of Edam cheese made with *L. rhamnosus* LC705 and *L. rhamnosus* GG ATCC53103 (LGG) was examined on the cavity [85]. This study announced that no differences were detected in *Streptococcus mutans* counts within the control group and the probiotic Edam cheese group; however, there was a tendency for the latter to decrease the high counts of *Streptococcus mutans*. The *Streptococcus mutans* has been decreased to 21% after 3 weeks in only 8% of the control group. The probiotic also can elevate the salivary lactobacilli counts which come during cheese manufacturing. No significant effects were detected in salivary microbial counts; however, the researchers reported that integrated probiotics in cheese could decrease dental caries.

The benefits of probiotic consumption on candidosis for elderly people were investigated by [86]. Ninety-two elderly people consumed cheese with a combination of *L. rhamnosus* GG, *L. rhamnosus* LC705, *Propionibacterium freundenreichii* spp., and *Shermani* JS to examine the microbiological analyses of oral yeasts four times in saliva samples. The counts of this microbial group (> 10^4 cfu/g) decreased to 25.0% and 20.7% after 8 and 16 weeks, respectively. Furthermore, the yeast population decreased by 75.0% in the probiotic group, and this risk increased by 34.0% in the nonprobiotic/control group. A positive tendency was also reported in the unstimulated saliva flow. Thus, the authors suggested that probiotics can affect the composition of saliva, the concentration of mucins, and salivary immunoglobulins. They concluded that probiotic cheese could be used as a prophylactic food which could decrease the hyposalivation and the dry mouth feeling. This, in turn, is beneficial to oral health.

9 Conclusion

Cheese is more effective than other dairy products to maintain and deliver viable probiotics into the human intestine. The minimum viable count of probiotic bacteria in many varieties of cheeses is 6.0 log cfu/g, and this is adequate to provide the health benefits at the time of consumption. This review concludes that probiotics do not affect the chemical composition of the cheese and they might influence the sensory characteristics (e.g., texture, flavor). As a result, the integrated probiotics should be selected carefully depending on the cheese conditions and processing parameters.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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