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A probiotic soy-based innovative product as an alternative to *petit-suisse* cheese

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ABSTRACT

The present study aimed to develop a probiotic soy-based product similar to *petit-suisse* cheese and to evaluate its perspectives regarding potential for consumer health benefits, sensory acceptability, and instrumental texture during storage. Three different trials were studied: MP (milk-based *petit-suisse* – control); MSP (mixed product with milk cream and soy); SP (soymilk-based product). The formulations were produced with an ABT culture, containing *Lactobacillus acidophilus* La-5, *Bifidobacterium animalis* Bb-12, and the starter *Streptococcus thermophilus* and stored at 4 °C for up to 28 days. Bb-12 viability remained always above 8 log cfu g^{-1} for all trials, whereas viability of La-5 was satisfactory at the end of storage for MP (7.56 log cfu g^{-1}) and MSP (6.49 log cfu g^{-1}), but only up to 21 days (6.84 log cfu g^{-1}) for SP. The pH remained stable and was lower for MSP ($p < 0.05$), whereas instrumental hardness and gumminess increased in soy-based products (MSP and SP) and decreased in the control (MP). SP had the highest sensory score means (6.4) on day 21, being sensorially attractive to provide consumers with a functional food without dairy ingredients and with high viability of the probiotic microorganisms.

1. Introduction

Most of the probiotic food products are milk-based, but factors like the preference for vegetarian food, problems with allergenicity or intolerance to dairy products has stimulated the use of non-dairy raw materials, especially those vegetable-based like soy, for the development of food products (Farnworth et al., 2007; Prado, Parada, Pandey, & Soccol, 2008).

Probiotic food products should retain stability during their shelf life, contain enough viable cells to confer health benefits, and be compatible with the product format to maintain desired sensory properties (Sanders, Gibson, Gill, & Guarner, 2007). However, to exert a health effect, the product needs to have more than beneficial nutritional characteristics. It must get to the consumer, which in turn depends on the food presenting a favourable flavour and, in general, attractive properties (Behrens, Roig, & Silva, 2004; Heenan, Adams, Hosken, & Fleet, 2004).

Probiotics and synbiotic *petit-suisse* cheeses were shown to be very promising, since they showed good conditions for maintaining the viability of probiotic microorganisms and rather peculiar and promising features for a functional food (Cardarelli, Buriti, Castro, & Saad, 2008; Pereira, Souza, Behrens, & Saad, 2010). However, the consumption of dairy products might be affected by the increasing number of individual with problems of allergenicity to milk proteins, high cholesterol levels, and lactose intolerance, besides the increased desire for vegetarian alternatives (Farnworth et al., 2007). In this line, a good raw material to be used as an alternative for non-dairy probiotic carrier is soy, since its lactose-free contents includes some sugars and amino acids used as substrates by lactic acid bacteria to produce aroma compounds (Ahmad, Li, Yang, Ning, & Randhawa, 2008). Several reports suggested that the relatively high concentrations of bioactive compounds present in soy, such as isoflavones and saponins, may contribute for reduction of the risk of various diseases (Behrens & Silva, 2004; Tseng & Xiong, 2009). In this context, soybeans have been considered as functional foods with a wide range of properties and appear as an interesting alternative to dairy products, promoting health through their intrinsic nutritional characteristics (Buckley et al., 2011). However, soy consumption is limited owing to its undesirable beany flavour and the presence of oligosaccharides (stachyose and raffinose) that often lead to flatulence and stomach discomfort (Yeo & Liong, 2010).

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One way to improve the sensory quality of soymilk and also to mask undesirable compounds is through lactic acid fermentation, which can be combined with supplemental sucrose, glucose, and lactose (Behrens et al., 2004; Cruz et al. 2009). Thereby, a fermented soy product prepared with probiotics would potentially lead to advantages in comparison with either soy or probiotic microorganisms alone (Buckley et al., 2011).

The development of a product similar to the probiotic *petit-suisse*, previously developed by our research group (Cardarelli et al., 2008; Saad, Cardarelli, & Maruyama, 2009), with the substitution of the dairy ingredients in the formulation by soy, is rather interesting and has good market prospects, particularly to supply, among other consumers, those with lactose intolerance or allergenicity to dairy proteins. Additionally, to our knowledge, little information regarding the effect of replacement of dairy ingredients by soy ingredients on the texture profile and the sensory acceptance in a probiotic soy cheese matrix is available in the scientific literature. Thus, this study aimed to develop a soy-based product somehow similar to *petit-suisse* cheese with an ABT culture, containing the probiotic microorganisms *Bifidobacterium animalis* Bb-12, *Lactobacillus acidophilus* La-5, and the starter *Streptococcus thermophilus*, as well as evaluating its perspectives regarding potential benefits for the consumer's health and sensory acceptability, as well its instrumental texture during storage at 4 ± 1 °C for up to 28 days.

2. Materials and methods

2.1. Experimental design and probiotic culture employed

Three formulations were produced, in triplicates (three different batches of the same formulation), for the physical-chemical and the microbiological analysis at five time points (1, 7, 14, 21, and 28 days of storage at 4 °C): MP, probiotic *petit-suisse* cheese prepared with quark cheese, as control (milk product); MSP, product with soy "cheese" and milk cream (mixed product with milk and soy), and SP, product with soy "cheese" and soy cream (soy product). The three formulations were produced with the probiotic ABT-4 culture (Christian Hansen, Valinhos, Brazil, freeze-dried DVS cultures for direct vat inoculation), containing the probiotic microorganisms *Bifidobacterium animalis* subsp. *lactis* Bb-12, *L. acidophilus* La-5, and the starter *S. thermophilus*.

2.2. Quark cheese preparation

For each production of quark cheese, pasteurized skimmed milk was employed (0.4–0.5% fat content, Salute, Descalvado, Brazil; high temperature short time [HTST]) and heated to 37–38 °C, calcium chloride (PA, Labsynth, Diadema, Brazil, 0.25 g L^{-1} milk) and ABT-4 culture (Christian Hansen, 1 g L^{-1} of milk). As soon as the pH reached values of about 6.3–6.4, commercial rennet Ha-La 1152 (chymosin from *Aspergillus niger* var. *awaroni*; Christian Hansen, Valinhos, Brazil, 30 mg L^{-1}) was added to the cheese-milk, which was allowed to set again until a curd was formed and the pH reached values of about 5.7. The gel was gently cut into cubes (20 × 20 × 20 mm), placed in sterilized cotton cheesecloth (Itatex, Itaporanga, Brazil), and allowed to drain at 15 °C for 15 h to be used as the cheese-base for the *petit-suisse* production.

2.3. Soy cheese preparation

For each production of soy cheese, soybeans cultivar BRS-257 (SL Alimentos Ltda., Mauá da Serra, Brazil) were employed. Soybeans (4 kg) were soaked in 8 L water for 16 h at 25 °C. After soaking, the wet beans were washed, weighed (typically 8.8 kg) and subsequently blended with water (310 g L^{-1}), using a kitchen blender (Magiclean, Arno, São Paulo, Brazil) for 10 min. Next, the dispersion was filtered in cotton cheesecloth to obtain the soymilk. Next, the soymilk was heated in a saucepan, under constant stirring, to 95 °C for 10 min. During heating, the saucepan was covered with an aluminium potlid to minimize evaporation. After the heating treatment, the soymilk was cooled in an ice-bath to 37 °C and transferred to a plastic heat preservation box (Invicta, Pouso Alegre, Brazil), when the ABT-4 culture was added (1 g L^{-1} of soymilk). The fermentation was allowed to continue until pH 4.8. Then, the gel was gently cut into cubes (20 × 20 × 20 mm), placed in sterilized cotton cheesecloth, and allowed to drain at 15 °C for 15 h. The fermentation was stopped at pH 5.7 and 4.8, for quark cheese and for soy cheese, respectively, in order to guarantee that the pH values of the final products were similar during the storage period of 28 days (around 4.3–4.5).

2.4. Petit-suisse cheese and soy-based products preparation

After draining, the cheese-base and the other ingredients (Table 1) were mixed in a Geiger UMMSK-12 pilot-scale mixer (12 kg capacity, 25 °C/1 atm; Geiger, Pinhais, Brazil). To produce the milk product (MP), quark cheese was employed, whereas soy cheese was used in the mixed product (MSP) and in the soy product (SP). Commercial sterilized milk cream (25 g fat, Nestlé, Araçatuba, Brazil) was added only in MP and MSP, and soy cream was added only in SP (20 g fat, Batavo, Brasil Foods S.A.). Xanthan Grindsted 80 (Danisco, Cotia, Brazil), carrageenan CY-500 (Danisco), and guar 250 (Danisco) were mixed with a portion of sucrose (about 20% of total sucrose). Next, they were mixed with pasteurized strawberry whole pulp (Icefruit Maisa, Mossoró, Brazil) in a blender (Arno, São Paulo, Brazil). This mixture, as well as the remaining sucrose (Coopersucar-União, Limeira, Brazil), natural colouring agent CA08076 (Citroaroma, Torrinha, Brazil), and artificial similar to natural strawberry flavour CA08069 (Citroaroma) were mixed in the Geiger mixer during 40 min. Subsequently, portions of 25 g of products were packaged in appropriate polypropylene plastic pots for food products (68 mm of diameter, 32 mm of height, 55 mL of total volume, Tries Aditivos Plásticos, São Paulo, Brazil) with a manual dispenser (Intelimaq model IQ81-A, Intelimaq Máquinas Inteligentes, São Paulo, Brazil) and sealed with a metallic cover with varnish in a sealer (Delgo Nr. 1968, Delgo Metalúrgica, Cotia, Brazil).

2.5. pH Measurements and chemical composition determination

The products pH values were determined in duplicate samples (two different pots of the same batch, totalling six pots for each

Table 1
Ingredients used for the production of *petit-suisse* cheese and soy-based products.

Ingredients (%)	Products		
	MP	MSP	SP
Quark cheese	61.995	–	–
Soy cheese	–	61.995	61.995
Sterilized milk cream (25% fat)	13.70	13.70	–
Soy cream (20% fat)	–	–	13.70
Sucrose	12.00	12.00	12.00
Pasteurized strawberry pulp	11.50	11.50	11.50
Guar gum	0.30	0.30	0.30
Carrageenan gum	0.1875	0.1875	0.1875
Xanthan gum	0.1875	0.1875	0.1875
Colouring agent	0.08	0.08	0.08
Artificial strawberry flavour	0.05	0.05	0.05
Total	100.0	100.0	100.0

MP: milk-based *petit-suisse*; MSP: mixed product with milk cream and soy; SP: soymilk-based product.