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Production of probiotic ice cream from goat's milk and effect of packaging materials on product quality

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ABSTRACT

A chocolate flavored probiotic ice cream was made from goat's milk using a probiotic bacterial culture comprising *Lactobacillus acidophilus* LA-5, *Bifidobacterium animalis* subsp. *lactis* BB-12, and novel probiotic *Propionibacterium jensenii* 702, and stored in three different packaging materials: polypropylene, polyethylene and glass. In order to assess the quality of the product, viability of the probiotic bacteria, the physico-chemical properties and sensory characteristics of the product in the different packaging materials were measured during storage. The freezing process during manufacturing of the ice cream was associated with a reduction in viable cell number, however the viable numbers of all probiotics remained 10^7 to 10^8 cfu g^{-1} up to 52 weeks at −20 °C regardless of the type of packaging. Packaging materials had a significant influence on the complete melting time of ice cream, and with the melting quality of the product as identified by the tasting panel, one week after production. The influence of packaging was not apparent in relation to other physico-chemical properties and sensory attributes of the product, while variation in certain sensory properties such as body and texture and taste of the product was apparent after 12 weeks storage.

1. Introduction

Probiotics have been defined as selective viable microorganisms that, following consumption with food have potential for improving the health and nutrition of the consumer due to their beneficial effects such as control of intestinal pathogens (Gilliland, 2003). With increased interest in their potential beneficial health effects, a number of different types of products have been proposed as carrier foods for probiotics. Ice cream is a well accepted food product (Cruz et al., 2009) and could therefore be an ideal vehicle for delivering probiotics to humans (Alamprese et al., 2005; Turgut and Cakmakci, 2009). Goat's milk possesses many advantages such as relatively lower allergenic burden, easier digestion and favorable properties to human nutrition and health (Silanikove et al., 2010). Furthermore, goat's milk can be utilized to produce ice cream with a softer texture and desirable melting characteristics (Ribeiro and Ribeiro, 2010). However, development of probiotic ice cream can be technologically challenging due to instability of probiotics in frozen products. Undesirable acidity development, freeze injuries and mechanical stress caused by agitation during mixing and freezing may contribute to the lower viability of probiotics in frozen dairy desserts. Furthermore, it is important that the incorporation of probiotics into ice cream does not affect the overall quality of the product. Therefore, physico-chemical parameters involved in the quality control of ice cream such as melting rate, and the sensory features of probiotic ice

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cream, should be comparable with conventional ice cream (Cruz et al., 2009).

Air incorporation during manufacturing is essential to obtain the desired physico-chemical quality parameters such as overrun in ice cream; however, excess oxygen may affect the growth of microaerophilic *Lactobacillus acidophilus* and anaerobic bifidobacteria (Kailasapathy and Sultana, 2003), and thereby decrease the probiotic value of the product. Oxygen permeation through the package may also have an adverse affect on probiotic viability (Shah, 2000). Although significant packaging effects on probiotic viability have been observed in some dairy products such as yogurt (Dave and Shah, 1997), study of the influence of the packaging materials on viability of probiotics in ice cream has been limited to date.

Sensory changes in food products may result from intended or unintended interactions with packaging materials and from failure of materials to protect product integrity or quality (Duncan et al., 2009). For example Linssen et al. (1992) observed the absorption of aroma compounds from flavored drink yogurts by high density polyethylene packaging materials. Packaging materials can also significantly influence the physico-chemical properties of probiotic dairy foods such as acidity during storage (Jayamanne and Adams, 2004). Such properties can directly affect the quality and ultimately the consumer acceptability of the product.

This paper examines the viability of *L. acidophilus* LA-5, *B. animalis* subsp. *lactis* BB-12 and the novel probiotic *P. jensenii* 702 in ice cream made from goat's milk, and evaluates the physico-chemical and sensory properties when the product is stored in different packaging materials in order to assess the quality of goat's milk probiotic ice cream during storage.

2. Materials and methods

2.1. Probiotic bacteria

Freeze dried probiotic cultures containing *L. acidophilus* LA-5 and *Bifidobacterium animalis* subsp. *lactis* BB-12 were obtained from CHR Hansen Pty Ltd (Bayswater, VIC, Australia). *P. jensenii* 702 was obtained from a stock culture maintained in the Laboratory of Microbiology, University of Newcastle, Australia.

2.2. Media, chemicals and growth conditions

MRS (deMann, Rogasa and Sharpe) – sorbitol agar (1% D-sorbitol/basal medium) and MRS-NNLP agar (MRS-nalidixic acid, neomycine sulphate, lithium chloride and paromomycine sulphate) were prepared for the selective enumeration of *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12 respectively (Dave and Shah, 1996). All chemicals used to prepare MRS-NNLP were obtained from Sigma–Aldrich Australia except neomycine sulphate (Oxoid Australia Ltd). Sodium lactate agar was used for the selective enumeration of *P. jensenii* 702 (Tharmaraj and Shah, 2003). All three probiotic bacteria were incubated anaerobically in jars containing AnaeroGen™ sachets (Oxoid Australia Ltd). Both *B. animalis* subsp. *lactis* BB-12 and *L. acidophilus* LA-5 were incubated at 37 °C for 72 h, while *P. jensenii* 702 was incubated at 30 °C for 5–7 days. Coliform counts were estimated using MacConkey agar incubated at 37 °C for 18 h. Yeast and mold enumeration was carried out on Rose Bengal-chloramphenicol agar, incubated at 25 °C for 5 days. Plate counting of all bacteria was conducted in triplicate at each time point, using the spread plate method.

2.3. Production of probiotic goat's milk ice cream

The ice cream was manufactured using homogenized and pasteurized goat's milk (Parmalat Australia Ltd., QLD 4101, Australia). Goat's cream was supplied from the Sherallee Goat Dairy, Cooranbong, NSW, Australia. Xanthan gum (Lotus Foods Pty Ltd, Australia), guar gum (Melbourne Food Ingredient Depot, Australia) and dextrose (Melbourne Food Ingredient Depot, Australia) were used as stabilizers. Commercial sugar (Woolworths, Australia) was used as a sweetener. Cocoa powder (Woolworths, Australia) was used to develop chocolate flavor. Vanillin (Queen Fine Foods Pty Ltd, Australia) was incorporated for further aroma development. Ice cream was formulated with the following composition (percentage by weight) to make 37–39 g/100 g total solids in the final product: milk 64.5, cream 15, sugar 12, cocoa powder 8, stabilizer 0.4 and vanillin 0.1.

The ice cream recipe was adopted from Akin et al. (2007) with modifications. Briefly, all the ingredients were mixed thoroughly and pasteurized at 85 °C for 30 min followed by aging at 4 °C for 12 h. A portion of the pasteurized goat's milk (15% w/w of total milk) was used to produce fermented milk by inoculating *L. acidophilus* LA-5, *B. animalis subsp. lactis* BB-12 and *P. jensenii* 702 cultures followed by anaerobic incubation at 37 °C for 1 h. By considering the starter culture manufacturer's instructions, high amount of starter cultures were inoculated when produce fermented milk in order to achieve higher level of probiotic counts (10^8 to 10^9 cfu/g) at the end of incubation period. The fermented milk was aged for approximately 12 h at 4 °C. The aged ice cream mixture and fermented milk were then well mixed in order to adjust the probiotic concentrations in the final mixture ($\sim 10^8$ cfu/g of each probiotic) just prior to ice cream manufacturing. The mixture was then frozen in a Krups GVS2 ice cream maker (Krups International, China). Samples (50 g) were drawn from the mixture after freezing, placed into polypropylene (Sistema, New Zealand & Sarstedt Australia Pty Ltd., Australia), polyethylene (Glad Products, Australia) or glass containers (Pyrex, USA), sealed, and stored at −20 °C. The experiment was repeated twice.

2.4. Microbiological analyses

Three samples of goat's milk ice cream from each type of packaging container were used to enumerate probiotic bacteria from the day of manufacturing up to 52 weeks of frozen storage. Colonies from the incubated plates were counted using a colony counter (Ratek Instruments Pty. Ltd., Boronia, Australia) and expressed as cfu/g. The fermented milk and ice cream mixtures, before and after freezing, were also assessed for probiotic bacteria using spread plate techniques. Coliform, yeast and mold counts were assessed on the day of production and again after 52 weeks of storage.

2.5. Physico-chemical analyses

The pH of probiotic goat's milk ice cream samples was measured using a Cyberscan 510 digital pH meter (EUTEOH Instruments, Singapore). Titratable acidity was measured by titrating 9 g of samples with 0.1 N NaOH solution. The total solids of samples were determined by drying samples at 105 ± 1 °C overnight to constant weight, using an air oven (Thermoline Scientific, Australia). The ash content was measured by ignition of solid materials at 550 °C in an electric muffle furnace (Labec Laboratory Pty Ltd, Marrickville, NSW, Australia). The fat and protein contents were determined by the Gerber method and Kjeldhal method respectively (James, 1995).

The overrun of ice cream samples were determined using the following formula (Akin et al., 2007),

$$\text{overrun} = \frac{W_1 - W_2}{W_2} \times 100$$

where W_1 = weight of unit mix; W_2 = weight of same volume of ice cream.

First dripping and complete melting times (in minutes) were determined as described by Akin et al. (2007), whereby 25 g of ice cream sample was left to melt at room temperature (20 °C) on a 0.2 cm wire mesh screen above a beaker. All physico-chemical properties were measured in triplicates.

2.6. Sensory evaluation

Sensory evaluation of goat's milk ice cream packed in glass, polyethylene and polypropylene was conducted by 29 (19 male and 10 female)