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Effect of galactooligosaccharide addition on the physical, optical, and sensory acceptance of vanilla ice cream

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ABSTRACT

The effect of the addition of galactooligosaccharide (GOS) on the physicochemical, optical, and sensory characteristics of ice cream was investigated. Vanilla ice cream was supplemented with 0, 1.5, and 3.0% (wt/wt) GOS and characterized for pH, firmness, color, melting, overrun, as well as subjected to a discriminative sensory test (triangle test). For comparison purposes, ice creams containing fructooligosaccharide were also manufactured. The GOS ice creams were characterized by increased firmness and lower melting rates. Different perceptions were reported in the sensory evaluation for the 3.0% GOS ice cream when compared with the control, which was not observed for the fructooligosaccharide ice cream. Overall, the findings suggest it is possible to produce GOS ice cream with improved stability in relation to the physicochemical parameters and sensory perception.
Key words: galactooligosaccharide, ice cream, stability, sensory perception

INTRODUCTION

Prebiotics are nonviable food components that confer health benefits to the host associated with modulation of the intestinal flora (FAO, 2007). From a technological point of view, they induce significant changes on the organoleptic characteristics of food products, enhancing flavor and texture (Al-Sheraji et al., 2013).

Galactooligosaccharides (**GOS**) are produced by the transgalactosylation of lactose by the enzyme β-galactosidase, occurring in lactose-rich substrates, notably milk, milk whey, or a mixture of both (Kothari et al., 2014). They are stable to adverse pH and temperature conditions, resistant at 160°C for 10 min at neutral pH or 120°C for the same period at pH 3. At pH 2, GOS is resistant at 100°C for up to 10 min (Sangwan et al., 2011). Their prebiotic effect is widely accepted, and several studies have reported the effect of their addition on the composition and activity of the intestinal flora (Krasaekoopt and Watcharapoka, 2014; Rattanaprasert et al., 2014; Bruno-Barcena. and Azcarate-Peril, 2015). However, no studies on the effect of GOS on food color were found in literature.

Ice creams and other refrigerated desserts are considered nutritive foods due to the presence of milk or fruits in their formulation, representing a source of proteins, vitamins, and minerals. As they are appreciated worldwide, regardless of culture, age, and socioeconomic level, the supplementation of ice creams with prebiotic ingredients or probiotic bacteria can add value to the product by providing functional appeal (Cruz et al., 2009). Several authors have already reported the functional potential of the ice cream matrix, and the addition of probiotic bacteria has been widely discussed (Alamprese et al., 2002, 2005; Fávaro-Trindade et al., 2007; Di Criscio et al., 2010), together with the sensory implications related to its addition (Soukoulis et al., 2010). The addition of other prebiotic ingredients, such as inulin and fructooligosaccharides, has also been investigated (Karaca et al., 2009). However, there is a lack of information on the effect of addition of GOS on the quality parameters of ice cream. Thus, the objective of the present study was to evaluate the effect of the addition of GOS on the physicochemical and optical properties and sensory acceptance of vanilla ice creams.

MATERIALS AND METHODS

Prebiotic Ingredient

The GOS mixture used in our study was produced by the activity of galactosyltransferases from *Scopulariopsis* spp. ATCC 44206, using lactose as substrate (Santos et al., 2009). The final product in the form

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of a dry powder that consisted of 28% (wt/wt) GOS with a degree of polymerization between 2 and 5, 50% lactose, 15% glucose, and 7% galactose. In addition, for comparative purposes, an ice cream with 3.0 g/100 g of fructooligosaccharide (**FOS**; Orafti, Tienen, Belgium) was produced, coded as F samples.

These prebiotics are traditionally used to enhance the sweetness level in food matrices. The percentage of prebiotics addition were based on the values established by the Brazilian legislation for these products, which recommends minimal concentration of 1.5 g per 100 g or 100 mL of product to provide the prebiotic effect (Brazil Ministry of Health, 2008).

Ice Cream Processing

Four ice creams were processed using a discontinuous domestic ice cream machine (Rival, São Paulo, SP, Brazil). The ice creams were supplemented with 0, 1.5, and 3.0 g/100 g of GOS (**C**, **1.5G**, and **3G**, respectively), proportional to the concentration of sucrose in the formulation. The amounts of the ingredients for each formulation are shown in Table 1 (Ferraz et al., 2012). Milk (Paulista, São Paulo, Brazil) was heated to 50°C and the glucose syrup (Doce Aroma, São Paulo, Brazil) was dissolved in warm milk. All the other ingredients were then added, including stabilizer (Duas Rodas, Jaraguá do Sul, Brazil), emulsifier (Lida, Diadema, Brazil), vanilla flavoring (Duas Rodas), milk powder (Itambé, Belo Horizonte, Brazil), vegetable fat (Vigor, São Caetano do Sul, Brazil), sucrose (Guarani, Olímpia, Brazil), and the prebiotics, according to Table 1. The ice cream mixtures were submitted to maturation at 5°C for 24 h before the air incorporation procedure (screw adjusted to 45%, 5 min, 5°C; Ferraz et al., 2012), packed into 100-mL propylene packs, sealed by thermo-induction, and stored frozen at −18°C. All experiments were performed at laboratory scale, in triplicate, as well as the physicochemical and optical analyses. The consumer preference test was performed once.

Table 1. Ice cream formulation[1]

Ingredients (g)	C	3F	1.5G	3G
Milk	500.0	500.0	500.0	500.0
Milk powder	35.0	35.0	35.0	35.0
Sucrose	150.0	147.0	148.5	147.0
Glucose syrup	25.0	25.0	25.0	25.0
Vegetable fat	15.0	15.0	15.0	15.0
Vanilla	10.0	10.0	10.0	10.0
Estabilizer	1.5	1.5	1.5	1.5
Emulsifier	1.0	1.0	1.0	1.0
Fructoligosaccharide (F)	—	3.0	—	—
Galactoligosaccharide (G)	—	—	1.5	3.0
Total	737.5	737.5	737.5	737.5

[1]C = 0 g/100 g of galactooligosaccharides (GOS); 3F = 3.0 g/100 g of fructooligosaccharides; 1.5G = 1.5 g/100 g of GOS; 3G = 3.0 g/100 g of GOS; the same formulation was used for the following experimental ice cream: F, 1.5G, and 3G, expect for sucrose content, which decreases proportionally, as 3, 1.5, and 3 g/100g respectively.

Physical and Optical Analyses

The ice creams were characterized for physicochemical (pH, firmness, melting, overrun) and optical analysis (instrumental color) after 45 d of frozen storage. All analyses were carried out at least in triplicate. The pH was determined using a digital pH meter (Micronal, Piracicaba, Brazil), by direct insertion of the electrode into the sample. The ice creams were maintained at 20°C during the analyses.

The melting rates of the ice cream samples were analyzed at room temperature (25 ± 2°C). Fifty-gram samples were weighed and placed in suspended sieves at controlled ambient temperature. The volumes of ice cream were measured over 40 min and the melting rates were calculated from the linear portion of each melting curve (Ferraz et al., 2012).

Air incorporation (overrun) was determined by comparing the weight of the mixture before and after freezing, and calculated according to Equation 1 (Di Criscio et al., 2010):

$$\text{Overrun (\%)} = [(\text{weight of ice cream} - \text{weight of liquid})/\text{weight of liquid}] \times 100. \quad [1]$$

Firmness was evaluated using the TA-XT2i texture analyzer (Stable Micro Systems, Godalming, UK), calibrated with a 25-kg load cell. The ice cream samples were maintained at −18°C until the analysis. During testing, the samples were compressed by penetration of a 2-mm-diameter aluminum cylinder probe. The tests were carried out in the compression power mode with a pretest speed of 2.0 mm/s, and test and post-test speeds of 1 mm/s, with a penetration distance of 10.0 mm. Three determinations were performed at approximately −18°C for each batch.

Color Quest II Hunterlab spectrophotometer (Reston, VA) was used for color determination according to the CIELCh system. In the $L^*C^*h_{ab}$ system, chroma (C^*) and hue angle (h_{ab}) were calculated from equations 2 and 3 (Vargas et al., 2008), respectively. The values for light and dark are represented by L (luminosity), red by $+a$, green by $-a$, yellow by $+b$, and blue by $-b$ in a Cartesian plane. Similar procedures were performed by Corradini et al. (2014):

$$C^* = [(a^*)^2 + (b^*)^2]^{1/2}; \quad [2]$$

$$h_{ab} = \tan^{-1}[b^*/a^*]. \quad [3]$$