Original

Mangaba (*Hancornia speciosa* Gomez) ice cream prepared with fat replacers and sugar substitutes

Sorvete de mangaba (Hancornia speciosa Gomez) preparado com substitutos de gordura e açúcar

Grazielle Gebrim SANTOS[1]*, Mara Reis SILVA[1]

Abstract

The effect of replacing shortening and sugar on the physical and chemical properties of mangaba ice cream and its acceptability were evaluated. Ice cream formulations were tested with the following fat replacers: Selecta Light, Litesse, and Dairy Lo and the following sugar substitutes: Lactitol and Splenda. All formulations were subjected to physical, chemical, and microbiological analyses and evaluated by acceptability tests. In the sensory analysis, it was observed a larger acceptance of the formulations containing Selecta Light (SL) and the combination of Litesse, Lactiol, and Splenda (LLS). The largest reduction in total energetic value (50%) was observed in the formulation LLS. The use of fat and/or sugar substitutes caused a reduction in the air incorporation (overrun) and affected viscosity. The highest melting speed was observed in the formulation with Dairy-Lo, Lactitol, and Splenda. All formulations showed good levels of global acceptability and appearance. The substitution of shortening for fat replacers caused a reduction in air incorporation and changes in ice-cream viscosity. The low-fat mangaba ice-cream elaborated with Selecta Light was the best formulation in terms of viscosity and air incorporation when compared with the control. It also showed a good level of acceptability and low fat content.
Keywords: *ice-cold foods; savannah fruit; low energetic value.*

Resumo

O efeito da substituição de gordura vegetal hidrogenada e sacarose nas propriedades físicas, químicas e aceitabilidade de sorvete com mangaba foi avaliado. As formulações de sorvete foram testadas com os substitutos de gordura: Selecta Light, Litesse e Dairy-Lo e os substitutos de sacarose: Lactitol e Splenda. As formulações foram submetidas às análises físicas, químicas, microbiológicas e teste de aceitação. Verificou-se no teste sensorial uma maior aceitação das formulações elaboradas com Selecta Light (SL) e combinação de Litesse, Lactitol e Splenda (LLS). A maior redução do valor energético (50%) foi observada na formulação LLS. A substituição de gordura, açúcar ou ambos promoveu a redução da incorporação de ar e afetou a viscosidade dos sorvetes elaborados. A maior velocidade de derretimento ocorreu na formulação com a combinação Dairy-Lo, Lactitol e Splenda. Todas as formulações tiveram bom nível de aceitação global e aparência. A substituição da gordura vegetal hidrogenada por substitutos de gordura promoveu uma redução da incorporação de ar e alterações da viscosidade dos sorvetes. Sorvete com mangaba, de reduzido valor energético, elaborado com Selecta Light teve o melhor desempenho quanto à viscosidade e incorporação de ar, em comparação ao controle, bom nível de aceitação e baixo teor de gordura.
Palavras-chave: *gelados comestíveis; fruto do cerrado; baixo valor calórico.*

1 Introduction

The Brazilian *cerrado* biome represents one of the most important areas of savannah vegetation diversity in the world. Several fruit species from this biome are potentially important for use as food products (SILVA et al., 2008; SANTOS et al., 2012). The inclusion of native fruits in daily diet is highly recommended by the World Health Organization as part of its Global Strategy on Diet, Physical Activity and Health (WORLD…, 2004). Mangaba (*Hancornia speciosa* Gomez) is a typical *Cerrado* biome fruit widely used in regional gastronomy and has recently attracted increasing interest due to its considerable potentialities which have stimulated its sustainable cultivation in the Brazilian Northeast and West Central Regions (SOUSA et al., 2005). Oliveira et al. (2005) used mangaba to prepare sherbet (a product made with water, sugar, fruit, milk solids, stabilizers, and colorings) and observed that higher pulp concentrations increased the apparent viscosity and soluble solids contents, and it also contributed to reduce free water in the mixture, a desirable characteristic in frozen desserts such as ice creams.

Ice cream is a complex colloidal emulsion containing fat globules, proteins, air bubbles, and ice crystals dispersed in an aqueous phase represented by a concentrated sugar solution (CLARKE, 2005). The chemical composition of ice cream determines several important structural and sensory parameters involved in the quality of the final product (GRANGER et al., 2005; SANTOS, 2009a). Conventional ice cream formulations have high concentrations of sugar and fat. However, increasing concerns about health and nutrition have given an impulse to the market of low calorie processed food, as well as of foods without shortening, a known source of trans fatty acids. Targeting these demands, the food industry has been seeking

Received 30/5/2011
Accepted 21/6/2012 (005316)
[1] *Faculdade de Nutrição, Universidade Federal de Goiás – UFG, CEP 74605-080, Goiânia, GO, Brasil, e-mail: grazinutrirte@gmail.com*
**Corresponding author*

DOI: http://dx.doi.org/10.1590/S0101-20612012005000086

alternative ingredients without major modifications in the conventional food characteristics, such as texture, flavor, and aroma (NABESHIMA et al., 2001). Fat can be replaced with similar ingredients combining carbohydrates, proteins, and fats (AMERICAN…, 2005; SANTOS, 2009b). Sugar substitutes, such as non-nutritious sweeteners, are used in small amounts to supply accentuated sweetness, and bulking agents are used in larger amounts to provide texture and replace the functional properties of sugar (AMERICAN…, 2004). Considering the great market potential for ice cream based on fruits from the Brazilian *cerrado,* as well as the importance of recipes with low energy value, the objective of this research was to investigate the technological viability, acceptance, and quality characteristics of ice cream elaborated with mangaba pulp using fat replacers and sugar substitutes (Selecta Light, Dairy-Lo, and Litesse and Lactitiol and Splenda, respectively).

2 Materials and methods

Mangaba pulp frozen at –18 °C in a cold chamber was provided by Sorveteria Milka Frutos do Cerrado (Goiás, Brazil). Milk (3.5% fat), cream (35% fat), sugar (white sugar), and shortening were obtained from the local market (Goiás, Brazil). The emulsifier (Stargel) and stabilizer (Starmix G-3), both from Kerry do Brasil, were obtained in São Paulo, Brazil. Dairy-Lo® (whey protein concentrate) was provided by Parmalat; Litesse® (polidextrose) and Lactitol CM (Milled Lactitol) by Danisco; Splenda® (Sucralose - micronized) by Tate & Lyle (São Paulo, Brazil); and the neutral base Selecta Light® (polydextrose, malt dextrin, sorbitol, modified starch, whey protein concentrate, sorbitol, acesulfame K, sucralose, guar gum, xanthan gum, salt, silicon dioxide, and Tricalcium phosphat) were provided by Duas Rodas (Goiás, Brazil).

The ice cream was prepared according to the five formulations presented in Table 1. The control formulation (C) was elaborated with all ingredients, except for the fat and sugar substitutes. The ice cream test formulations were elaborated according to Brazilian specific legislation for diet and light products (BRASIL, 1998). According to Brazilian Legislation, diet products are foods without added sucrose and those with a maximum of 0.5 g of reference disaccharides per 100 g of food in the final product for consumption. However, the denomination light is allowed when the fat content of the final product does not exceed 3 g.100 g^{-1}. Fat and sugar substitutes were included in the formulations according to the legislation and manufacturer recommendations. Sugar was substituted for a combination of Lactitol (bulking agent) and Splenda (high intensity nonnutritive sweetener). The SL formulation was prepared by partial substitution of sugar and total substitution of shortening for Selecta Light. The LLS formulation was prepared by substituting fat for Litesse and sugar for Lactitol and Splenda. The DL and DLS formulations were elaborated by substituting shortening for Dairy Lo. However, in the formula DLS, sugar was totally substituted for Lactitol and Splenda.

2.1 Ice cream processing

Ice cream was manufactured according to Marshall et al. (2003). Base ice cream mix was standardized to contain 6% fat, 5% nonfat milk solids, 12% sugar, and 0.4% stabilizer. Twenty four hours prior to ice cream preparation, the temperature of the frozen mangaba pulp was raised to 2 °C. The ingredients (except mangaba pulp and emulsifier) were hand mixed and pasteurized at 70 °C for 30 minutes, followed by cooling to 10 °C in an ice bath. For maturation, the mixture was cooled to 4 °C and maintained at this temperature for 5 hours with manual stirring every thirty minutes. The mangaba pulp and the emulsifier were added to the mixture at the end of the maturation process by homogenization in an industrial blender for 4 minutes. The mix was then subjected to whipping and was frozen at –5 °C to reach the desired consistency before being transferred to a 2-liter polyethylene container and placed in a walk-in freezer at –25 °C for 48 hours for hardening.

Table 1. Tested formulas for elaborate mangaba ice cream.

Ingredients	Formulas [a, b]									
	C		SL		LLS		DL		DLS	
	kg	%	kg	%	kg	%	kg	%	kg	%
Sugar	1.68	12.1	0.84	6.3	-	-	1.68	12.2	-	-
Dairy cream	0.56	4.0	0.56	4.2	0.56	4.2	0.56	4.1	0.56	4.4
Dairy-Lo	-	-	-	-	-	-	0.24	1.7	0.24	1.9
Emulsifier	0.063	0.5	0.063	0.5	0.063	0.5	0.063	0.5	0.063	0.5
Shortening	0.39	2.8	-	-	-	-	-		-	
Lactitol	-	-	-	-	0.588	4.4	-		0.588	4.6
Whole milk	7	50.3	7	52.6	7	52.5	7	50.9	7	55.3
Stabilizer	0.21	1.5	0.21	1.6	0.21	1.6	0.21	1.5	0.21	1.7
Litesse	-	-	-	-	0.91	6.8	-		-	
Mangaba pulp	4	28.8	4	30.1	4	30.0	4	29.1	4	31.6
Selecta Light	-	-	0.63	4.7	-	-	-		-	
Splenda	-	-	-	-	0.003	0.02	-	-	0.003	0.02

[a] Formulas: C- control elaborated with all the ingredients except the fat replacers and sugar substitutes; SL- partial substitution of sucrose and shortening by Selecta Light; LLS- substitution of shortening by Litesse and total sucrose by Lactitol and Splenda; DL- substitution of shortening by Dairy Lo; DLS- substitution of shortening by Dairy Lo, and sucrose by Lactitol and Splenda. [b] %: Percentage in relation to total value, obtained from the sum of the total ingredients mass.

2.2 Microbiological analyses

Microbiological analyses were performed according to the methods described in the Compendium of Methods for the Microbiological Examination of Foods (DOWNES; ITO, 2001) and microbiological standards compared to those defined by RDC nº 12 (BRASIL, 2001). The microbiological analyses carried out in mangaba pulp and ice creams included the counts of total and fecal coliforms, the examination for positive-coagulase *Staphylococcus,* and *Salmonella* spp. (BRASIL, 2001).

2.3 Sensory analyses

Ice cream acceptability was evaluated using affective laboratory tests with 40 untrained potential consumers. Overall acceptance (flavor, odor, and texture) was evaluated in individual cabins with red light, where 30 g of each sample was presented to the panelists in a monadic way in disposable coded plastic cups placed in appropriate thermal holders to keep the ice cream temperature between –12 °C and –8 °C. A nine-point structured hedonic scale anchored at the appearance of each product was judged at random using this hedonic scale. For this purpose, the samples were placed in white plastic cups numbered with three digits, arranged in thermal holders using natural daylight illumination. The test was approved by the Ethics Committee in Research of the Federal University of Goiás (Protocol nº 022/2007).

2.4 Physical and chemical analyses of ice cream formulations

Total solids, moisture, and ash contents were determined by gravimetric methods and nitrogen by the micro-Kjeldahl method (ASSOCIATION…, 1990). The lipid content was determined by the Bligh and Dyer (1959) method, and the amount of carbohydrates was calculated by difference. In the case of the formulations tested, this was considered to be the proportion of carbohydrate derived substitutes. The pH was determined using a potentiometer (alpax, Pa 200), and the titratable acidity was obtained by titration with 0.1N NaOH (INSTITUTO…, 2005). The apparent viscosity of the melted ice cream samples was determined using a Brookfield model DV-II + viscometer and a Tecnal TE-183 refrigeration unit to maintain the temperature at 5 °C ± 0.2 °C. The readings were made at 12 rpm with spindle # 3 and the results expressed in centipoises (cP) after 30 seconds of rotation (DERVISOGLU; YAZICI, 2006). Melting was analyzed using a 0.3 cm wire mesh by placing 70 ± 5 g of ice cream (–10 °C ± 2 °C) on the wire mesh and allowing it to melt at room temperature (25 °C ± 1 °C) for 60 minutes. The melted ice cream was collected in a beaker placed beneath the wire mesh and weighed every 10 minutes. Time of melting was taken using a stopwatch (Oregon model C510Y) (DERVISOGLU; YAZICI, 2006). Overrun was determined by measuring the mix volume before and after cooling using a standard 100 mL cup and was calculated as follows: *Overrun* = [(ice cream volume – mix volume)/ mix volume] × 100 (DERVISOGLU, 2006). The color parameters were analyzed using a Hunterlab Colorquest II colorimeter taking readings of the parameters L* (lightness), *a** (from green to red), and *b** (from blue to yellow) after standardization of the equipment previously calibrated with standard green (*L** = 57.64, *a** = –19.48, *b** = 10.34).

2.5 Total energy value

To estimate the total energy value of the ice cream, the following conversion values were used: 4 kcal.g^{-1} for carbohydrates and proteins and 9 kcal.g^{-1} for lipids (MERRILL; WATT, 1973). A factor of 2.4 kcal.g^{-1} was used for Lactitol, 1 kcal.g^{-1} for Litesse (polydextrose), and zero for Splenda (sucralose), according to their proportions in the formulations, in accordance with the labeling rules provided by the Agência Nacional de Vigilância Sanitária (BRASIL, 2003). Fat replacers and sugar substitutes, which are proteins and carbohydrates, were subtracted from the total concentration determined in the chemical analyses to estimate the energetic value.

2.6 Statistical analysis

The experiments were carried out using a completely randomized design with three replicates. The results of the physical, chemical, and sensory analyses were submitted to ANOVA and the Tukey test (α = 0.05), and the melting test data were submitted to regression analysis using Statistica program, version 7.0 Demo (STATSOFT, 2008).

3 Results and discussion

Regarding the microbiological characteristics, mangaba pulp and ice cream samples did not show detectable levels of fecal coliforms, *Staphylococcus,* and *Salmonella* according to Brazilian legislation (BRASIL, 2001).

In the acceptability test, all formulations were well accepted (Table 2) since the average values for the overall acceptance were above 6 (liked slightly). With the exception of SL, the formulations did not differ significantly from the control (C). Those results were higher than those obtained by Chen et al. (2010), who analyzed low-fat content ice creams enriched with 2%, 3%, and 4% of polysaccharides extracted from soybeans as fiber source. The average global acceptance scores in the hedonic scale varied from 5 to 6.2, but the ice creams with higher percentage of fiber obtained the lowest acceptance averages.

Table 2. Sensory acceptability of the mangaba ice cream formulas.

Formulas[1]	Scores	
	Overall acceptance	Appearance
C	6.75 ± 1.58[b]	7.58 ± 1.50[a]
SL	7.58 ± 1.39[a]	7.48 ± 1.66[a]
LLS	7.38 ± 1.41[a,b]	7.92 ± 1.31[a]
DLS	7.25 ± 1.71[a,b]	7.38 ± 1.63[a]
DL	7.08 ± 1.64[a,b]	7.55 ± 1.50[a]

[1]Formulas: C- control elaborated with all the ingredients except the fat replacers and sugar substitutes; SL- partial substitution of sucrose and shortening by Selecta Light; LLS- substitution of shortening by Litesse and total sucrose by Lactitol and Splenda; DL- substitution of shortening by Dairy Lo; DLS- substitution of shortening by Dairy Lo, and sucrose by Lactitol and Splenda. Data with means ± standard deviations for 40 replicates/sample. Means followed by the same letter in the same column do not differ significantly at 5% probability according to the Tukey test.

It can be seen from the score distributions that the most accepted formulation was SL, followed by LLS, since 60% and 52.5%, respectively, of the scores attributed by the panelists were higher or equal to 8 (liked very much), as shown in Figure 1. Taking into account that the segmentation of the results, according to the frequency of the scores, may help the comparison of the results of the average test, the SL formulations, followed by LLS, had the best results in the global acceptability test.

No observations were made by the panelists regarding the overall characteristics or any perception of sweeteners. All formulations were also accepted regarding appearance (Table 2). Although some differences were observed among the formulations in the color test, visual evaluation was similar for all ice creams, and the average values of appearance were higher than 7 (liked moderately).

The replacement of fat and sugar caused a significant reduction in the total solids content of the mangaba ice cream (Table 3). According to Soler and Veiga (2001), the contents of these ingredients, especially sugar, are associated with the total solids content of ice cream. The shortening and sugar were totally replaced in the DLS formulation, which caused an increase in the moisture content resulting in an ice cream with a higher content of freezable water and less overrun. The water and total solids contents of the formulations differed significantly among the formulations ($P < 0.05$). The higher moisture content observed in the DLS formulation was due to its lower solids concentration when compared to the other formulations. In traditional ice creams prepared with milk, the total solid contents vary from 28 to 40% (CLARKE, 2005).

The low pH observed in the formulations was possibly due to the addition of mangaba pulp to the mixture (Table 3). Fruit free ice creams, such as vanilla and chocolate flavors, present pH values around 6.0, and standard ice cream formulations have a pH of 6.3 (BAER; WOLKOW; KASPERSON, 1997). Regarding titratable acidity, the highest value was observed in the LLS formulation, which differed from the others due to the total substitution of shortening for Litesse (polydextrose) and of sugar for Splenda and Lactitol.

The replacement of sugar and shortening strongly affected the ice cream overrun and apparent viscosity (Table 3). In the SL formulation, the substitution of the shortening for Selecta Light caused an increase in apparent viscosity, probably due to the presence of whey protein concentrate, malt dextrin, and

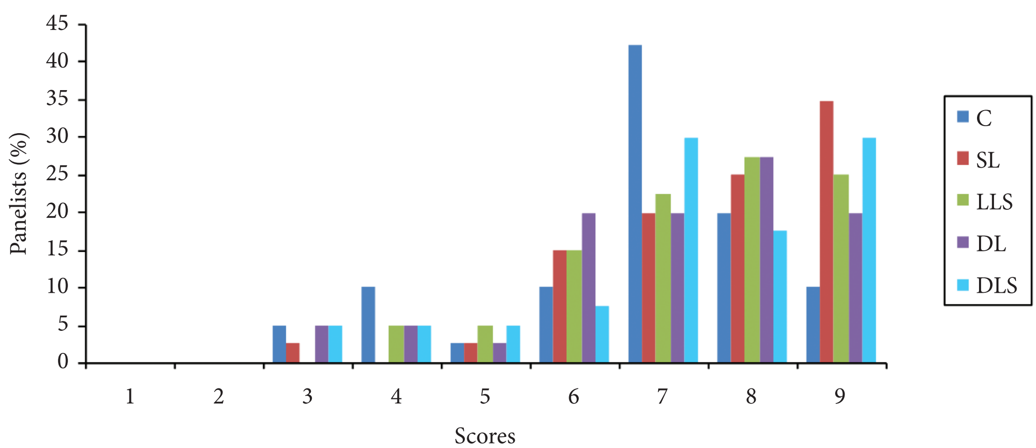

Figure 1. Scores for overall acceptance attributed by the panelists to mangaba ice cream formulas: C- control elaborated with all the ingredients except the fat replacers and sugar substitutes; SL- partial substitution of sucrose and shortening by Selecta Light; LLS- substitution of shortening by Litesse and total sucrose by Lactitol and Splenda; DL- substitution of shortening by Dairy Lo; DLS- substitution of shortening by Dairy Lo, and sucrose by Lactitol and Splenda.

Table 3. Results of the physicochemical analyses of the control and test formulas.

Formulas[1]	Characteristics					
	Moisture (g.100 g^{-1})	Titratable acidity (%)	pH	Total solids (g.100 g^{-1})	Viscosity (cP)	*Overrun* (%)
C	71.64 ± 0.01[e]	5.28 ± 0.04[c]	4.61 ± 0.01[c]	28.36 ± 0.01[a]	237.47 ± 6.83[b]	48.28 ± 1.12[a]
SL	75.19 ± 0.02[b]	5.26 ± 0.11[c]	4.63 ± 0.01[c]	24.81 ± 0.02[d]	292.77 ± 4.69[a]	33.14 ± 0.68[b]
LLS	74.21 ± 0.06[c]	6.40 ± 0.04[a]	4.50 ± 0.01[d]	25.79 ± 0.06[c]	172.80 ± 7.12[c]	24.66 ± 0.60[c]
DL	72.52 ± 0.01[d]	5.92 ± 0.03[b]	4.76 ± 0.02[b]	27.48 ± 0.01[b]	285.37 ± 6.34[a]	22.45 ± 0.29[d]
DLS	79.04 ± 0.04[a]	5.85 ± 0.01[b]	4.94 ± 0.01[a]	20.96 ± 0.04[e]	176.53 ± 1.55[c]	24.48 ± 0.52[c]

[1]Formulas: C- control elaborated with all the ingredients except the fat replacers and sugar substitutes; SL- partial substitution of sucrose and shortening by Selecta Light; LLS- substitution of shortening by Litesse and total sucrose by Lactitol and Splenda; DL- substitution of shortening by Dairy Lo; DLS- substitution of shortening by Dairy Lo, and sucrose by Lactitol and Splenda. Means followed by the same letter in the same column do not differ significantly at 5% probability according to the Tukey test.

modified starch in the Selecta Light. According to Aime et al. (2001), fat substitutes derived from carbohydrates are associated with increases in apparent viscosity in ice creams.

The DL formulation showed an increase in apparent viscosity related to the addition of a fat substitute derived from protein (Dairy-Lo). Yilsay, Yilmaz and Bayizit (2006) also reported an increase in apparent viscosity in vanilla ice cream elaborated with Simplesse (whey protein concentrate) as fat replacer. Viscosity of formulations SL and DL were similar and significantly higher than that of the control suggesting that the replacement of fat for carbohydrates and whey proteins might be effective in increasing ice cream viscosity. However, in the DLS formulations, also prepared with Dairy-Lo but with total replacement of sugar for Lactitol and Splenda, the apparent viscosity was lower due to the low total solids content (Table 3), which is responsible for the apparent viscosity in ice creams. On the contrary, in the LLS and DLS formulations, there was a reduction in apparent viscosity, possibly due to the total replacement of sugar.

Total replacement of shortening resulted in significant modifications in the ice cream overrun. All formulations tested presented a reduction in overrun when compared to the control; the greatest reduction was observed in the DL formulation (Table 3). Rossa, Burin and Bordignon-Luiz (2012) reported an inverse correlation between fat concentration and air incorporation in ice creams with 4 to 8 g.100 g^{-1} of fat, elaborated with transglutaminaze enzyme, which is able to change functional properties of proteins. However, in the present study, the highest air incorporation was observed in the SL ice cream with 3.65 g.100 g^{-1} of fat, and the lowest was observed in the DL formulation with 3.97 g.100^{-1} of fat, when compared to the control.

Smet et al. (2010) evaluated the overrun of ice creams with different kind of fats and verified that the average value (101.1%) was much higher than those obtained in this study. However, those authors tested formulations without adding fruits and with high content of non-fat solids from milk (12.2%).

All formulations showed air incorporation below 50%, which is common in homemade ice cream recipes (FREELAND-GRAVES; PECKHAM, 1996). Whey proteins have the ability to stabilize foam emulsions besides favoring air incorporation (FOEGEDING et al., 2002); however, the concentration of Dairy-Lo used was not sufficient to maintain the overrun in the DL formulation.

The protein concentration of SL was similar to that of the control, differing significantly from DL and DLS formulations, possibly due to the substitution of the shortening for whey protein concentrate (Dairy-Lo). The differences observed in the protein concentrations of the SL and LLS formulations may be attributed to the low protein content of the fat replacers (Selecta Light) used in the SL formulation. The lowest lipid values were observed in the SL and LLS formulations. The higher lipid concentration observed in DLS formulation was influenced by the reduction in total solids, resulting from the total replacement of sugar and shortening (Table 4).

The increased ice cream overrun values resulted from the considerable destabilization of the fat globules in the homogenization process, resulting in lower meltdown speeds (SOFJAN; HARTEL, 2004). In the processing of the mangaba ice cream, homogenization was carried out without using an industrial scale homogenizer, resulting in reduced destabilization of the fat globules and consequently in lower overrun and higher melting speeds. The reduction in lipid contents of the formulations tested, as compared to the control, varied from 37 to 45%, which affected the energy content reduction from 12 to 50%. The association of fat and sugar substitutes in the LLS and DLS formulations caused reductions in the total energy value of 50% and 44%, respectively (Table 5). However, the reduction in the DL formulation was only 12% due to the replacement of shortening by whey protein concentrate, which supplied 4 kcal.g^{-1}. It is likely that changes in apparent viscosity and overrun on ice cream were not sufficient to affect the overall acceptance since the panelists did not mention changes in these attributes in the acceptability test.

Regarding color analyses, the values for lightness (L^*) were close to those of the control (C), with the exception of LLS and DLS formulations (Table 6). All formulations showed low lightness values (black) and positive values for the parameter a^* (red), but only the SL and LLS formulations differed significantly from the control demonstrating that the use of Selecta Light and Litesse changed the color of the ice cream with a reduction in the a^* value. The differences in the values for b^* were not significant, and therefore no relationship could be established between the

Table 4. Chemical analyses and total energy value (VET) of the ice cream formulas.

Formulas[1]	Analyses				
	VET (kcal.100 g^{-1})	Protein (g.100 g^{-1})	Total lipids (g.100^{-1})	Carbohydrates (g.100 g^{-1})	Ash (g.100 g^{-1})
C	145.21 ± 0.23^a	1.89 ± 0.02^d	6.68 ± 0.07^a	19.39 ± 0.15^b	0.48 ± 0.01^c
SL	104.37 ± 0.48^c	1.94 ± 0.04^d	3.65 ± 0.08^d	18.66 ± 0.02^c	0.54 ± 0.01^b
LLS	72.76 ± 0.61^e	2.22 ± 0.03^c	3.77 ± 0.07^d	19.31 ± 0.03^b	0.49 ± 0.01^c
DL	127.55 ± 0.23^b	2.77 ± 0.05^b	3.97 ± 0.05^c	20.18 ± 0.01^a	0.56 ± $0.01^{a,b}$
DLS	81.50 ± 0.54^d	2.92 ± 0.04^a	4.23 ± 0.09^b	13.22 ± 0.12^d	0.58 ± 0.01^a

[1]Formulas: C- control elaborated with all the ingredients except the fat replacers and sugar substitutes; SL- partial substitution of sucrose and shortening by Selecta Light; LLS- substitution of shortening by Litesse and total sucrose by Lactitol and Splenda; DL- substitution of shortening by Dairy Lo; DLS- substitution of shortening by Dairy Lo, and sucrose by Lactitol and Splenda. Means followed by the same letter in the same column do not differ significantly at 5% probability according to the Tukey test.

variability in b^* and the use of substitutes. Similar results were reported by Dervisoglu (2006).

In the meltdown tests, with the exception of DLS, all formulations presented an initial dripping time (10 minutes) similar to that of the control. However, they all showed a tendency for a positive linear meltdown (Figure 2). The substitution of sugar and shortening for Dairy-Lo, Lactitol and Splenda increased the melting rate of DLS formulation. At the end of the test (60 minutes), 82% of the initial weight of DLS had melted (70 ± 0.5 g), whereas only 50 to 78% of the other formulations and 42% of the control had melted. Rossa, Burin and Bordignon-Luiz (2012) observed that ice creams with 8 g.100 g^{-1} of fat showed higher resistance to melting compared to ice creams with 4 to 6 g.100^{-1} of fat. However, in the present study, a relationship between mangaba ice creams fat concentration and resistance to melting was not observed. Possibly, the fat substitutes used were not effective in increasing ice cream stability causing melting increase when compared to control. Nabeshima et al. (2001) evaluated the physical characteristics of vanilla ice cream elaborated with the following fat and sugar substitutes, Simplesse and Litesse, and concluded that they increased the meltdown speed.

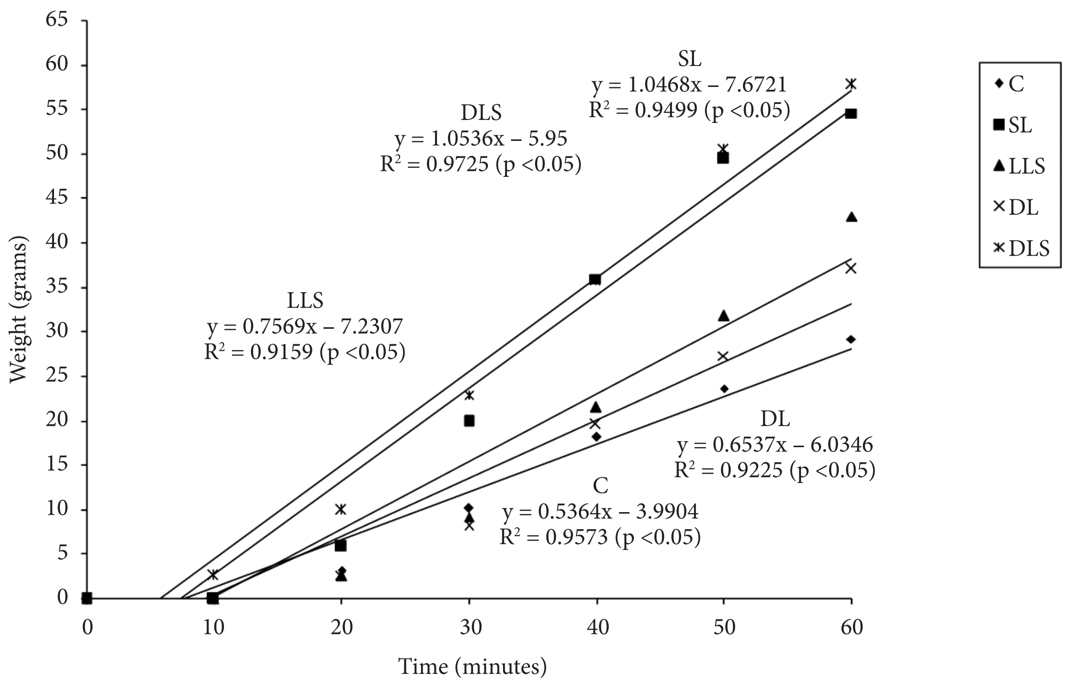

Figure 2. Variation in mangaba ice cream formulas melted at room temperature (25 ± 1.0 °C).Formulas: C- control elaborated with all the ingredients except the fat replacers and ssugar substitutes; SL- partial substitution of sucrose and shortening by Selecta Light; LLS- substitution of shortening by Litesse and total sucrose by Lactitol and Splenda; DL- substitution of shortening by Dairy Lo; DLS- substitution of shortening by Dairy Lo, and sucrose by Lactitol and Splenda.

Table 5. Characteristics of the formulas tested as compared to the control (C) with respect to the Total Energy Value (VET), lipids and sugar.

Characteristics	Formulas[1]			
	SL	LLS	DL	DLS
Reduction in VET (%)	28.0	50.0	12.0	44.0
Reduction in VET (kcal)	41.0	72.0	18.0	64.0
Lipid Reduction (%)	45.0	44.0	41.0	37.0
Sugar (%)	67.0	-	100.0	-
Formula classification	Light	Diet	Low fat	Diet

[1]Formulas: SL- partial substitution of sucrose and shortening by Selecta Light; LLS- substitution of shortening by Litesse and total sucrose by Lactitol and Splenda; DL- substitution of shortening by Dairy Lo; DLS- substitution of shortening by Dairy Lo, and sucrose by Lactitol and Splenda.As compared to the control formula (C) containing 145.21 kcal, 6.68% lipid, 19.63% sugar and 1.89% protein according to brazilian legislation (BRASIL, 2003).

Table 6. Color parameters for the mangaba ice cream formulas and control.

Formulas[1]	Hunter values		
	L^*	a^*	b^*
C	7.46 ± 0.22^{b}	20.13 ± 0.06^{a}	0.23 ± 0.04^{a}
SL	7.83 ± 0.24^{a,b}	19.77 ± 0.04^{b}	–0.38 ± 0.20^{a}
LLS	5.93 ± 0.44^{c}	18.12 ± 0.09^{c}	0.10 ± 0.28^{a}
DL	7.01 ± 0.37^{b}	19.98 ± 0.10^{a,b}	–0.30 ± 0.40^{a}
DLS	8.81 ± 0.28^{a}	20.18 ± 0.03^{a}	–0.52 ± 0.18^{a}

[1]Formulas: C- control elaborated with all the ingredients except the fat replacers and sugar substitutes; SL- partial substitution of sucrose and shortening by Selecta Light; LLS- substitution of shortening by Litesse and total sucrose by Lactitol and Splenda; DL- substitution of shortening by Dairy Lo; DLS- substitution of shortening by Dairy Lo, and sucrose by Lactitol and Splenda. Means followed by the same letter in the same column do not differ significantly at 5% probability according to the Tukey test. Color scale of the International Lightness Commission L* a* b* (HUNTERLAB, 1996).

4 Conclusions

The chemical composition and apparent viscosity of the ice cream formulations tested were affected by the type and concentration of substitutes used for shortening and sugar. The use of substitutes for shortening, sugar, or both contributed to a reduction of up to 50% in energy value of the mangaba ice cream, reduced the overrun, and increased the melting speed. The "diet" and "light" ice creams elaborated with mangaba were accepted by potential consumers. The best chemical, physical, and sensory quality characteristics were observed in the formulas containing Selecta Light. The ice cream with mangaba and Selecta light had the best performance regarding viscosity and overrun, when compared to control, besides showing a good level of acceptability, low shortening content, and reduced total energetic value.

Acknowledgements

The authors are grateful to Danisco Sweeteners, Kerry do Brasil, Tovani Benzaquen Representações, Cooperativa Mista dos Produtores de Leite de Morrinhos (Complem), Duas Rodas Industrial, Sorveteria Milka Frutos do Cerrado and Gelatti Indústria e Comércio de Sorvetes for their support.

References

AMERICAN DIETETIC ASSOCIATION – ADA. Position of the American Dietetic Association: use of nutritive and nonnutritive sweeteners. **Journal of the American Dietetic Association**, v. 104, n. 2, p. 255-275, 2004. http://dx.doi.org/10.1016/j.jada.2003.12.001

AMERICAN DIETETIC ASSOCIATION – ADA. Position of the American Dietetic Association: fat replacers. **Journal of the American Dietetic Association**, v. 105, n. 2, p. 266-275, 2005. http://dx.doi.org/10.1016/j.jada.2004.12.011

AIME, D. B. et al. Textural analysis of fat reduced vanilla ice cream products. **Food Research International**, v. 34, n. 2-3, p. 237-246, 2001. http://dx.doi.org/10.1016/S0963-9969(00)00160-5

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS – AOAC. **Official methods of analysis**. 15. ed. Arlington: AOAC, 1990.

BAER, R. J.; WOLKOW, M. D.; KASPERSON, K. M. Effect of emulsifiers on the body and texture of low fat ice cream. **Journal of Dairy Science**, v. 80, n. 12, p. 3123-3132, 1997. http://dx.doi.org/10.3168/jds.S0022-0302(97)76283-0

BLIGH, E. G.; DYER, W. J. A rapid method of total lipid extraction and purification. **Canadian Journal of Biochemistry and Physiology**, v. 37, n. 8, p. 911-917, 1959. http://dx.doi.org/10.1139/o59-099

BRASIL. Resolução RDC nº 12, de 02 de janeiro de 2001. Regulamento técnico sobre padrões microbiológicos para alimentos. **Diário Oficial da República Federativa do Brasil**, Brasília, DF, 10 jan. 2001.

BRASIL. Resolução RDC nº 360, de 23 de dezembro de 2003. Aprova o regulamento técnico sobre rotulagem nutricional de alimentos embalados, tornando obrigatória a rotulagem nutricional. **Diário Oficial da República Federativa do Brasil**, Brasília, DF, 26 dez. 2003.

BRASIL. Secretaria de Vigilância Sanitária. Portaria nº 29, de 13 de janeiro de 1998. Alimentos para fins especiais. **Diário Oficial da República Federativa do Brasil**, Brasília, DF, 15 jan. 1998.

CHEN, W. et al. Addition of soluble soybean polysaccharides to dairy products as a source of dietary fiber. **Journal of Food Science**, v. 75, n. 6, p. C478-C484, 2010. http://dx.doi.org/10.1111/j.1750-3841.2010.01688.x

CLARKE, C. The science of ice cream. **Chemistry and Industry**, v. 24, n. 19, p. 22-23, 2005.

DERVISOGLU, M. Influence of hazelnut flour and skin addition on the physical, chemical and sensory properties of vanilla ice cream. **International Journal of Food Science and Technology**, v. 41, n. 6, p. 657-661, 2006. http://dx.doi.org/10.1111/j.1365-2621.2005.01127.x

DERVISOGLU, M.; YAZICI, F. The effect of citrus fibre on the physical, chemical and sensory properties of ice cream. **Food Science Technology International**, v. 12, n. 2, p. 159-164, 2006. http://dx.doi.org/10.1177/1082013206064005

DOWNES, F. P.; ITO, K. **Compendium of methods for the microbiological examination of foods**. 4th ed. Washington: American Public Health Association, 2001.

FOEGEDING, E. A. et al. Advances in modifying and understanding whey protein functionality. **Trends in Food Science and Technology**, v. 2, n. 13, p. 151-159, 2002. http://dx.doi.org/10.1016/S0924-2244(02)00111-5

FREELAND-GRAVES, J. H.; PECKHAM, G. C. **Foundations of food preparation**. 6th ed. New Jersey: Prentice-Hall, 1996.

GRANGER, C. et al. Influence of formulation on the structural networks in ice cream. **International Dairy Journal**, v. 15, n. 3, p. 255-262, 2005. http://dx.doi.org/10.1016/j.idairyj.2004.07.009

HUNTERLAB. CIE L*a*b* color scale. **Applications Note**, v. 8, n. 7, p. 1-15, 1996. Disponível em: <www.hunterlab.com/appnotes/an07_96a.pdf>. Acesso em: 02 jun. 2010.

INSTITUTO ADOLFO LUTZ – IAL. **Métodos físico-químicos para análise de alimentos**. 4. ed. Brasília: Ministério da Saúde, 2005. (Série A. Normas e Manuais Técnicos).

MARSHALL, R. T. et al. **Ice cream**. 6th ed. Springer: New York, 2003. http://dx.doi.org/10.1007/978-1-4615-0163-3

MERRILL, A. L.; WATT, B. K. **Energy value of foods**: basis and derivation. Washington: United States Department of Agriculture, 1973.

NABESHIMA, E. H. et al. Propriedades físicas do sorvete de baunilha elaborado com substitutos de gordura e sacarose. **Boletim Centro de Pesquisa e Processamento de Alimentos**, v. 19, n. 2, p. 169-182, 2001.

OLIVEIRA, A. L. et al. Propriedades físicas de misturas para *sherbet* de mangaba. **Pesquisa Agropecuária Brasileira**, v. 40, n. 6, p. 581-586, 2005. http://dx.doi.org/10.1590/S0100-204X2005000600008

ROSSA, P. N.; BURIN, V. M.; BORDIGNON-LUIZ, M. T. Effect of microbial transglutaminase on functional and rheological properties of ice cream with different fat contents. **LWT - Food Science and Technology**, v. 48, n .2 , p. 224-230, 2012.

SANTOS, G. G. Sorvete: processamento, tecnologia e substitutos de sacarose. **Ensaios e Ciência**, v. 13, n. 02, p. 95-109, 2009a.

SANTOS, G. G. Substitutos de gordura. **Nutrição Brasil**, v. 08, n. 05, p. 323-328, 2009b.

SANTOS, G. G. et al. Aceitabilidade e qualidade físico-química de paçocas elaboradas com amêndoa de baru. **Pesquisa Agropecuária Tropical**, v. 42, n. 2, p. 159-165, 2012.

SILVA, M. R. et al. Caracterização química de frutos nativos do cerrado. **Ciência Rural**, v. 38, n. 06, p.1790-1793, 2008. http://dx.doi.org/10.1590/S0103-84782008000600051

SMET, K. et al. Influence of Milk fat acid composition and process parameters on the quqlity of ice cream. **Dairy Science and Tecnology**, v. 90, n. 4, p. 431-447, 2010. http://dx.doi.org/10.1051/dst/2010006

SOFJAN, R. P.; HARTEL, R. W. Effects of overrun on structural and physical characteristics of ice cream. **International Dairy Journal**, v. 14, n. 3, p. 255-262, 2004. http://dx.doi.org/10.1016/j.idairyj.2003.08.005

SOLER, M. P.; VEIGA, P G. **Sorvetes**. Campinas: ITAL/CIAL, 2001.

SOUSA, C. S. et al. Mangaba: perspectivas e potencialidades. **Bahia Agrícola**, v. 7, n. 1, p. 29-31, 2005.

STATSOFT. **Statistica**. Tulsa: Stat Soft Inc., 2007. versão Demo.

STONE, H.; SIDEL, J. L. Affective testing. In: STONE, H.; SIDEL, J. L. **Sensory evaluation practices.** Boca Raton: Academic Press, 1985. p. 227-252.

WORLD HEALTH ORGANIZATION – WHO. **Global strategy on diet, physical activity and health**. Geneva: WHO, 2004.

YILSAY, T. O.; YILMAZ, L.; BAYIZIT, A. A. The effect of using a whey protein fat replacer on textural and sensory characteristics of low-fat vanilla ice cream. **European Food and research Technology**, v. 222, n. 1-2, p. 171-175, 2006.