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Effects of tropical fruit pulps and partially hydrolysed galactomannan from *Caesalpinia pulcherrima* seeds on the dietary fibre content, probiotic viability, texture and sensory features of goat dairy beverages

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ABSTRACT

The use of cheese whey and probiotic cultures in the production of dairy beverages has been highly attractive; nonetheless, whey-based goat beverages tend to be poor and watery when compared to fermented milks. The addition of fruits and fibre ingredients might improve texture and mouthfeel of this kind of product. Fermented whey-based goat beverages prepared using *Streptococcus thermophilus* TA-40 as starter culture, with added guava or soursop pulps, and with or without addition of partially hydrolysed galactomannan from *Caesalpinia pulcherrima* seeds (PHGM), showed to be good vehicles for *Bifidobacterium animalis* subsp. *lactis* BB-12 and *Lactobacillus rhamnosus* Lr-32, maintaining their viability above 7 log CFU/ml during 21 days. PHGM increased the dietary fibre content and enhanced the instrumental texture and sensory features of both guava and soursop dairy beverages, especially texture, appearance, and overall acceptability. The PHGM might be recommended to improve nutritional and sensory quality of fermented probiotic beverages produced with goat milk and cheese whey.

1. Introduction

Cheese whey is the major by-product from the cheese industry, with a yield of 60–90 g/100 g in relation to the total milk coagulated during the manufacture depending on the cheese type, representing a significant source of protein and energy (Almeida, Tamime, & Oliveira, 2008). In the specific case of goat cheese whey produced in Brazil, the most part of goat cheese production occurs in small- or medium-sized dairy plants and this by-product is often discarded without any treatment as an effluent, becoming in a strong pollutant (Tranjan et al., 2009). As an alternative, the use of cheese whey in the production of dairy beverages has been a highly attractive option, particularly due to its nutritional value (Almeida et al., 2008).

In relation to the development of whey based beverages, a point that deserves special attention in food industry is the texture. Texture and mouthfeel of fermented whey based beverages tend to be poor and watery when compared with that of fermented milks, since the liquid whey contains low percentage of total solids (ca. 6 g/100 g). Moreover, the consumers of dairy beverages expect that, even with the addition of whey, these products should have similar aspect and texture to those found in their traditional equivalents (Gallardo-Escamilla, Kelly, & Delahunty, 2007). This sensory matching is more difficult in goat dairy beverages, which presents a less favourable protein profile to reach a firm structure (Park, Juárez, Ramos, & Haelein, 2007).

In general, yogurt and fermented beverages prepared with goat milk tend to have a less firm texture when compared to the similar cow milk products. This characteristic is commonly attributed to the lower concentration of caseins in goat milk, besides differences in the proportions of α_s-caseins and in the micelle size (Park et al., 2007). The production of fermented dairy beverages with fluid goat whey may imply in the formation of a less firm gel, which probably would affect consumers' acceptability.

The addition of fruits and fibre ingredients appears as alternative to improve the sensory acceptability of whey-based goat beverages (Tranjan et al., 2009), besides contributing with nutrients which are

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not contained in milk, particularly dietary fibre (do Espírito Santo et al., 2012). Guava (*Psidium guajava*) and soursop (*Annona muricata*) are fruits largely grown in tropical regions (Ramírez & Pacheco de Delahaye, 2011). These fruits are consumed either in the *in natura* form or added, specially their pulps, to several food products (Dantas, Pereira, Ribeiro, Maia, & Bassoi, 2007; de Lima, Alves, & Filgueiras, 2006; Ramírez & Pacheco de Delahaye, 2011).

Caesalpinia pulcherrima (EN: Dwarf Poinciana, Pride of Barbados; PT: flamboyant-mirim, flamboyanzinho) is a plant from the family Fabaceae – Leguminosae and largely found in Brazil, even in the semi-arid areas (Buriti et al., 2014). Its seeds accumulate considerable amounts of galactomannan (Cerqueira et al., 2009) with potential applications in the food industry, as a texture modifier and source of dietary fibre. Since the galactomannan from *C. pulcherrima* seeds shows high viscosity when in solution even at low concentrations, this polysaccharide needs to be partially hydrolysed for use as an alternative dietary fibre source in liquid food products. Our previous study indicated that partially hydrolysed galactomannan from *C. pulcherrima* would be advisable to be added as a dietary fibre ingredient in liquid and semi-solid products containing commercial cultures commonly used in dairy industry (Buriti et al., 2014).

The use of probiotic cultures during the fermentation of goat dairy products would bring additional benefits to the consumer's health associated with the maintenance of an optimum microbial balance in the digestive tract (Kongo, Gomes, & Malcata, 2006; Salva et al., 2011; Senaka Ranadheera, Evans, Adams, & Baines, 2012). Nonetheless, fruit juices and pulps are components that may interfere in the survivability of probiotic microorganisms added to food products (Buriti, Komatsu, & Saad, 2007; Vinderola, Costa, Regenhardt, & Reinheimer, 2002). The effects of fruits on the viability of probiotic bacteria, therefore, deserve to be investigated in products where these components are combined.

The aim of the present study was to evaluate the influence of guava pulp, soursop pulp and partially hydrolysed galactomannan from *C. pulcherrima* (PHGM) on the physicochemical parameters, dietary fibre content, probiotic viability, texture profile and sensory features of fermented beverages produced with goat milk, goat cheese whey, *Streptococcus thermophilus* as starter culture, and *Bifidobacterium animalis* and *Lactobacillus rhamnosus* as probiotic adjuncts.

2. Material and methods

2.1. Production of the partially hydrolysed galactomannan

The pods of *C. pulcherrima* were collected in the cities of Fortaleza, Quixeramobim and Sobral (Ceará State, Brazil), between September 2009 and August 2010. A voucher specimen of *C. pulcherrima* seeds has been deposited at Herbarium Prisco Bezerra – EAC (Federal University of Ceará, Fortaleza, Brazil) under the number 44718.

The polysaccharide extraction was based on the procedures described by Cerqueira et al. (2009). Seeds were removed from the pods, cleaned and placed in a blender to be mechanically broken down. Afterwards, the endosperm was manually separated from the germ and the hull and suspended in ethanol (96 ml/100 ml) in a 1:3 proportion (seeds:ethanol) at 70 °C for 15 min to inactivate the enzymes and eliminate the low-molecular-weight compounds. The ethanol was decanted, distilled water was added in a 1:5 proportion (endosperm:water), and the suspension was left to rest overnight. The next day, water was added in a 1:10 proportion (suspension:water) and mixed in a blender for 5 min. Next, the viscous solution was filtered through a nylon net and precipitated by adding ethanol at a ratio of 1:2. The precipitate was successively washed with acetone, dried with hot air and milled. The product obtained in this step – intact galactomannan from *C. pulcherrima* seeds – was denoted as GM.

In the following step, GM was dissolved in distilled water to a concentration of 15 g/L under constant stirring for 3 h at room temperature, using a mechanical mixer Fisatom (model 713, São Paulo, Brazil), starting at 1000 rpm, with subsequent increase up to 2000 rpm, in order to form a uniform gel. For the enzymatic hydrolysis, a commercial cellulase from *Aspergillus niger* (1.24 U/mg, Sigma, Buchs, Switzerland) was dissolved in distilled water to achieve a concentration of 6.4 U/mL. The enzyme dispersion was added to the polysaccharide suspension in a proportion of 12.8 U of cellulase to 1 g of galactomannan. The gel was stirred for 2 h at room temperature, with a successive decrease from 2000 rpm to 1000 rpm. The hydrolysed suspension was transferred to borosilicate flasks with caps, and immediately autoclaved at 121 °C for 20 min. The suspension was cooled, passed through a sieve (0.25 mm opening) and dried in a mini spray dryer Büchi (model B-290, Flawil, Switzerland), using an inlet temperature of 160 °C, an outlet temperature of 103–107 °C, an air flow of 538 L/h and pump speed of 233 mL/h. The product obtained in this step – partially hydrolysed galactomannan from *C. pulcherrima* seeds – was denoted as PHGM. The weight average molar mass (M_w) and the total dietary fibre content of PHGM were 2.47×10^5 g/mol and 78.27 g/100 g, respectively (Buriti et al., 2014).

2.2. Production of the dairy beverages

Four pilot-scale dairy beverage-making trials with guava pulp, soursop pulp, guava pulp plus PHGM and soursop pulp plus PHGM – denoted T1, T2, T3 and T4, respectively – were prepared in three batches: one batch of 3.6 kg (for all analyses, including sensory evaluation) and two batches of 1 kg (for other analyses than sensory evaluation). For this purpose, a fermented milk-whey base was prepared with pasteurised goat milk (44.585 g/100 g), goat cheese whey (44.585 g/100 g), granulated sucrose (Estrela – Usina Estivas, LDC Bioenergia, Rio Grande do Norte, Brazil, 10.778 g/100 g), *B. animalis* subsp. *lactis* (BB-12® Probiotic culture – Probiotec®, Chr. Hansen, Hørsholm, Denmark, 0.024 g/100 g), *L. rhamnosus* (Lr-32 Florafit™ Probiotics, Danisco, Madison, WI, USA, 0.024 g/100 g), and *S. thermophilus* (TA-40 Yo-Mix™ Yogurt Cultures, Danisco, Sassenage, France, 0.004 g/100 g). The pasteurised goat milk was produced at Goats' Milk Technological Centre of Embrapa Goats and Sheep, Sobral, Ceará State, Brazil. The whey was previously obtained during the processing of a caprine Coalho cheese batch, as described by Egito and Laguna (1999). The whey was portioned in nylon plastic bags, mixed with sucrose, heated at 85 °C during 30 min, cooled and stored at −21 ± 2 °C up to the moment of its use. For the production of the fermented milk-whey base, the pasteurised goat milk was incorporated to the mixture whey-sucrose and heated at 43 ± 2 °C for the addition of the starter culture *S. thermophilus* and the probiotic cultures *B. animalis* subsp. *lactis* and *L. rhamnosus*. After that, the milk-whey base was kept at 43 ± 2 °C for 3 h in order to achieve pH around 5.0. Next, the temperature of the fermented milk-whey base was decreased to 4 °C up to the following day for the addition of the further ingredients, in the proportions described in Table 1. The frozen pasteurised fruit pulps used in this study are commercial products from a regional agroindustry (Frute, Antonio Vander Almeida Vieira – EPP, Caucaia, Brazil) purchased in grocery stores. Guava pulp was added in trials T1 and T3, and soursop pulp was added in trials T2 and T4. The partially hydrolysed galactomannan of *C. pulcherrima* was added in trials T3 and T4. All the ingredients were mixed in a blender in order to form a homogeneous product. The beverages were packed in plastic bottles (high density polyethylene, ca. 200 g) and stored at 4 ± 1 °C for 21 days.

Table 1
Ingredients used for the production of the goat dairy beverages T1, T2, T3 and T4.

Ingredients[a]	T1	T2	T3	T4
Fermented milk-whey base (g/100 g)	85.0	85.0	83.5	83.5
Guava pulp (concentrated and frozen)[b] (g/100 g)	15.0	–	15.0	–
Soursop pulp (concentrated and frozen)[b] (g/100 g)	–	15.0	–	15.0
PHGM[c] (g/100 g)	–	–	1.5	1.5
Total (g/100 g)	100.0	100.0	100.0	100.0

[a] A dash indicates that the ingredient is absent.
[b] Frute (Antonio Vander Almeida Vieira – EPP, Caucaia, Brazil).
[c] Partially hydrolysed galactomannan from *C. pulcherrima*.

2.3. Sampling periods

Dairy beverages from each batch were sampled for analysis after 1, 7, 14 and 21 days of storage. The milk-whey base was also sampled during the manufacture process immediately after the addition of the starter and probiotic cultures (0 h), at the end of fermentation (ca. 3 h), and after cooling at 4 °C prior to addition of fruit pulps (24 h).

2.4. Mean composition of dairy beverages

Total solids, ash, fat and protein content of dairy beverages were determined on the first day of storage, in duplicate, for the three batches of each trial. Total solids were determined through drying 5 g samples at 70 °C under vacuum using a vacuum oven Marconi (model MA 030/12 Piracicaba, Brazil). Ash was determined gravimetrically by heating the dried samples at 550 °C. Analytical procedures for the determination of total solids and ash content of samples followed the standard methods of the Instituto Adolfo Lutz (IAL, 2008). Fat was determined according to Folch, Less, and Stanley (1957). Protein was estimated by measuring the nitrogen content of samples through the micro Kjeldahl method and multiplying by a conversion factor (6.38), according to the AOAC official methods 690.52 and 991.20 (AOAC, 2005). Total dietary fibre of samples was determined after 1 and 21 days of storage for the three batches of each trial according to the AOAC method 985.29 (AOAC, 2005).

2.5. Physicochemical and microbiological analysis

The pH values, titratable acidity, and viability of the starter (*S. thermophilus*) and the probiotic (*B. animalis* and *L. rhamnosus*) bacteria were determined in triplicate during the manufacture process of the milk-whey bases and throughout the storage of the dairy beverages for the three batches of each trial, according to the sampling periods previously described. The pH values of samples were measured with a pH meter Tecnal (model TEC 3P MP, Piracicaba, Brazil). Titratable acidity was determined according to the appropriate standard methods and expressed in terms of g/100 g lactic acid (IAL, 2008). For the microbiological analysis, 1.0 ml of sample was transferred aseptically to 9.0 ml of buffered peptone water (1 g/L) and submitted to serial dilutions with the same diluent. Populations of *S. thermophilus* were determined by pour-plating 1 ml of each dilution in M17 agar with added lactose (Vetec, Duque de Caxias, Brazil, 5 g/L), followed by incubation at 37 °C (Buriti, Okazaki, Alegro, & Saad, 2007), for 48 h. Populations of *B. animalis* were determined by pour plating 1 ml of each dilution in modified DeMan–Rogosa–Sharpe (MRS) agar (Oxoid, Basingstoke, UK), prepared as a basal medium, to which dicloxacillin (Sigma, St. Louis, MO, USA), cysteine hydrochloride (Cromoline®, Diadema, Brazil) and lithium chloride (Cinética®, Jandira, Brazil) sterile solutions were added to reach a concentration of 0.5 mg/L, 0.5 g/L and 1 g/L, respectively, followed by anaerobic incubation (Anaerobic System Anaerogen, Oxoid) at 37 °C for 72 h (Buriti, Okazaki et al., 2007). Populations of *L. rhamnosus* were determined by pour-plating 1 ml of each dilution in MRS agar (Oxoid) acidified to pH 5.4 with acetic acid (Almeida et al., 2008), followed by incubation at 37 °C for 72 h.

2.6. Textural measurement

Instrumental texture of dairy beverages during the storage was evaluated for each batch in duplicate with a TA-XTplus Texture Analyser (Stable Micro Systems, Surrey, UK), using the back extrusion test. An acrylic compression disc (35 mm diameter) was thrusted into a cylindrical container (50 mm diameter × 70 mm height) filled with samples at 4 °C up to a height of 50 mm (ca. 100 ml). The starting distance of the disc was set at 30 mm above the top of the sample surface. The disc penetrated into the sample to a depth of 30 mm at a 1 mm/s speed, and returned at 10 mm/s speed. The parameters measured consisted of firmness, consistency, cohesiveness and index of viscosity, obtained by using the Exponent Lite © 2007 software – version 4.0.13 (Stable Micro Systems).

2.7. Sensory evaluation

The sensory evaluation of the present study was approved by the State University of Vale do Acaraú Human Ethics Research Committee – Sobral, Ceará State, Brazil (Process No. 458401; CAAE: 0073.0.039.000-1; Protocol No: 1037) and was carried out at the Laboratory of Sensory Analysis of Embrapa Goats and Sheep. The dairy beverages were evaluated after 7, 14 and 21 days of refrigerated storage (4 ± 1 °C) through acceptability tests, using the hybrid hedonic scale (0 = disliked extremely, 5 = neither liked nor disliked, 10 = liked extremely) (Lawless & Heymann, 2010; Villanueva & Da Silva, 2009), focussing on attributes of flavour, texture, appearance and colour, and also on the overall acceptability. On each sampling day, 40 consumers (untrained panellists) of the research centre, particularly staff, researchers and fellow students, were recruited, based, primarily, on interest and goat dairy products consuming habits. Panellists with poor physical conditions, as described by Meilgaard, Civille, and Carr (1999), were excused from the sessions. The samples were maintained under refrigeration prior the tests and served, monadically, in individual disposable plastic cups codified with three random digits. During a session, each consumer analysed three different trials (balanced incomplete blocks), totalising 30 evaluations per trial in each sampling day. Most of the consumers participated in more than one session. The consumers were also instructed to report the sensory attributes related to flavour, texture, appearance and aroma that they liked and disliked most in the samples, and they were free to mention none or more than one attribute. The percentage of evaluations performed by females and males were, respectively, 44.4% and 55.6%. The age of consumers ranged from 19 to 60 years old, and 50% of the evaluations were from consumers between 27 and 44 years old (interquartile range).

2.8. Statistical analysis

The results were presented as means ± standard deviation (SD). Differences between trials and experimental storage period were statistically analysed using analysis of variance (ANOVA), followed by the *post hoc* Tukey test, with $P < 0.05$. Before ANOVA evaluation, data were checked for the normality and homogeneity of variances using the Shapiro–Wilk and Bartlett tests, respectively. When this assumption was not verified, the equivalent non-parametric tests were applied. For the data on total dietary fibre, pH, titratable

acidity, microbial viability, texture parameters and sensory evaluation the following model was considered: $y_{ijk} = \mu + x_{1i} + x_{2j} + \varepsilon_{ijk}$, where y_{ijk} is the dependent variable, μ is the overall mean, x_{1i} is the trial effect, x_{2j} is the storage period effect and ε_{ijk} is the residual random error. Statistical analysis was performed using SAS (Statistical Analysis Systems) software version 9.2 (SAS Institute Inc., Cary, NC, USA).

3. Results and discussion

3.1. Mean composition of dairy beverages

The mean composition of dairy beverages is shown in Table 2. There was no significant difference between trials in relation to the fat content in whole sample and in dry matter basis, and concerning the ash and protein content in whole sample ($P > 0.05$). On the other hand, the ash and protein contents in dry matter tended to be lower in beverages T3 and T4, prepared with the addition of PHGM, which was expected due to the higher proportion of carbohydrate added to these trials. Beverage T3 presented the lowest protein content in dry matter and differed significantly from T1 and T2 ($P < 0.05$). Beverage T4 differed significantly from T2 in relation to ash and protein in dry matter ($P < 0.05$). Pulps of guava and soursop were, respectively, the sole source of dietary fibre in beverages T1 and T2. Ramírez and Pacheco de Delahaye (2009) reported a significantly higher total dietary fibre (TDF) content in the dry matter of flours produced with edible portions of guava fruits (65.64 ± 0.48 g/100 g) compared with soursop fruits (49.34 ± 0.66 g/100 g) ($P < 0.05$). TDF content in beverage T1, in whole sample and dry matter basis, tended to be higher than T2 during the storage; nonetheless, the content of this nutrient did not differ significantly between trials T1 and T2 at 1 and 21 days of storage ($P > 0.05$). The addition of PHGM at 1.5 g/100 g in beverages T3 and T4 increased significantly their total solids and TDF content in whole sample and dry matter in comparison with T1 and T2 ($P < 0.05$). Although the TDF content tended to decrease in all trials after 21 days of storage at 4 ± 1 °C in relation to day 1, no significant difference during the studied period was observed ($P > 0.05$). According to the current Brazilian legislation, the beverages T3 and T4 could be classified as source of dietary fibre, since their TDF content is higher than 2.5 g in their customarily consumed serving portion per eating occasion, being a cup or 200 ml for this kind of product (ANVISA, 2003, 2012). On the other hand, beverages T1 and T2, only added with pulp fruits, were not able to fulfil this standard.

Table 2
Physicochemical analysis (mean ± SD)[a] of dairy beverages T1, T2, T3 and T4. See Table 1 for the description of the goat dairy beverages.

Item	Trials			
	T1	T2	T3	T4
Total solids (g/100 g)	19.90 ± 1.04^{A}	19.79 ± 0.92^{A}	21.24 ± 0.34^{B}	21.44 ± 0.47^{B}
Fat (g/100 g)				
WM[b]	1.44 ± 0.17	1.43 ± 0.38	1.36 ± 0.12	1.41 ± 0.23
DM[c]	7.24 ± 0.66	7.16 ± 1.68	6.41 ± 0.57	6.56 ± 0.96
Ash (g/100 g)				
WM	0.62 ± 0.02	0.63 ± 0.05	0.63 ± 0.01	0.63 ± 0.04
DM	3.14 ± 0.13^{AB}	3.20 ± 0.16^{B}	2.98 ± 0.08^{AB}	2.94 ± 0.20^{A}
Protein (g/100 g)				
WM	1.42 ± 0.13	1.51 ± 0.09	1.39 ± 0.08	1.44 ± 0.10
DM	7.11 ± 0.37^{BC}	7.63 ± 0.32^{C}	6.54 ± 0.30^{A}	6.71 ± 0.35^{AB}
TDF[d] (g/100 g)				
WM − day 1	0.84 ± 0.17^{B}	0.62 ± 0.32^{B}	2.25 ± 0.24^{A}	1.95 ± 0.34^{A}
WM − day 21	0.70 ± 0.14^{B}	0.36 ± 0.21^{B}	1.98 ± 0.17^{A}	1.64 ± 0.28^{A}
DM − day 1	4.20 ± 0.69^{B}	3.09 ± 1.49^{B}	10.57 ± 0.96^{A}	9.09 ± 1.51^{A}
DM − day 21	3.55 ± 0.92^{B}	1.86 ± 1.18^{B}	9.33 ± 0.92^{A}	7.68 ± 1.38^{A}
pH				
Day 1	4.17 ± 0.05	4.11 ± 0.04	4.17 ± 0.07	4.13 ± 0.03
Day 7	4.19 ± 0.04	4.10 ± 0.04	4.14 ± 0.04	4.14 ± 0.05
Day 14	4.18 ± 0.04	4.10 ± 0.08	4.18 ± 0.03	4.11 ± 0.06
Day 21	4.15 ± 0.05	4.12 ± 0.02	4.15 ± 0.03	4.12 ± 0.04
Overall mean	4.17 ± 0.05^{B}	4.11 ± 0.05^{A}	4.16 ± 0.04^{B}	4.13 ± 0.05^{A}
Titratable acidity (g/100 g)				
Day 1	0.623 ± 0.029	0.700 ± 0.010	0.625 ± 0.031	0.683 ± 0.011
Day 7	0.638 ± 0.022	0.695 ± 0.007	0.641 ± 0.038	0.691 ± 0.008
Day 14	0.659 ± 0.031	0.696 ± 0.008	0.656 ± 0.039	0.678 ± 0.009
Day 21	0.682 ± 0.032	0.698 ± 0.013	0.678 ± 0.046	0.682 ± 0.025
Overall mean	0.652 ± 0.036^{A}	0.697 ± 0.010^{C}	0.651 ± 0.042^{A}	0.683 ± 0.015^{B}

$^{A–C}$ The different superscript capital letters in a same row denote significant differences ($P < 0.05$) between trials. Time effect was not significant for TDF, pH and titratable acidity ($P > 0.05$).

[a] Six measurements for total solids, fat, ash, and protein (three batches, in duplicate); three measurements for TDF (one per batch) at each sampling day; nine measurements for pH and titratable acidity (three batches, in triplicate) at each sampling day.

[b] WM = Whole matter.

[c] DM = Dry matter.

[d] TDF = Total dietary fibre.

3.2. Physicochemical and microbiological parameters of dairy beverages

During the 3 h of fermentation the pH of milk-whey base reduced significantly from 6.37 to 5.03 ($P < 0.05$), with a significant increase in the titratable acidity from 0.134 g/100 g–0.402 g/100 g ($P < 0.05$). Significant changes continued to occur during the overnight period in which the milk-whey base was cooled at 4 ± 1 °C, reaching a pH and an acidity of 4.47 and 0.498 g/100 g, respectively, prior to the addition of the further ingredients for the production of the dairy beverages ($P < 0.05$). The population of *S. thermophilus* increased significantly during the fermentation process, from 7.58 log CFU/ml to 9.05 log CFU/ml ($P < 0.05$), and remained stable during the cooling process, with a viability of 9.29 log CFU/ml. The population of *B. animalis* started at 8.13 log CFU/ml and did not alter significantly during the production of the milk-whey base, neither during fermentation nor during the cooling process ($P > 0.05$), reaching a viability of 8.05 log CFU/ml after this period. On the contrary, the population of *L. rhamnosus* presented a smaller, although significant, increase during the fermentation process ($P < 0.05$), from 6.91 log CFU/ml to 7.13 log CFU/ml, and also another significant increase during the cooling process ($P < 0.05$), reaching a viability of 8.11 log CFU/ml.

The pH and titratable acidity values of dairy beverages T1–T4 during 21 days of storage at 4 ± 1 °C are shown in Table 2. On the first day of storage, the pH of beverages T1–T4 was between 4.10 and 4.20, which were lower than the pH found for milk-whey during the cooling process (4.47). This occurred due to the addition of guava and soursop pulps, which presented pH of 3.99 ± 0.33 and 3.68 ± 0.02, respectively. Ramírez and Pacheco de Delahaye (2011) observed pH values of 3.9 ± 0.01 and 3.7 ± 0.00, respectively, for guava and soursop pulps, which differed significantly in that study ($P < 0.05$). Due to the addition of pulp fruits, the titratable acidity values of beverages T1–T4 on day 1, between 0.600 g/100 g and 0.700 g/100 g (Table 2),were higher than that found for the milk-whey base on the day of processing (0.498 g/100 g). The pH values and titratable acidity of beverages T1–T4 did not differed significantly between the sampling periods during the storage at 4 ± 1 °C ($P > 0.05$). Nonetheless, considering the entire storage period, T2 and T4 presented lower pH and higher titratable acidity, differing significantly from T1 and T4 ($P < 0.05$), possibly due to the lower pH verified for soursop pulp in comparison with the guava pulp. The dairy beverage T2 presented the highest titratable acidity throughout the whole storage period, and also differed significantly from T4, added with PHGM ($P < 0.05$).

The viability of *S. thermophilus* (starter), *B. animalis* and *L. rhamnosus* (probiotics) in the dairy beverages during storage is shown in Table 3. Taking into account each storage period and each microorganism separately, it was observed that the populations were very similar for the beverages T1–T4, without significant differences between the trials concerning the viability of these microorganisms ($P > 0.05$). The population of *S. thermophilus* was higher than 9 log CFU/ml on the first day of storage, without significant difference from the values observed at days 7 and 14. After 21 days, the viability of *S. thermophilus* decreased significantly compared to day 1 ($P < 0.05$), with a total reduction of 0.5 log cycle during this period. In relation to *B. animalis*, the viability of this microorganism was around 8 log CFU/ml; however, it reduced significantly during the storage ($P < 0.05$), with a total decrease of 1 log cycle after 21 days. On the other hand, the viability of *L. rhamnosus* was considerably stable in beverages T1–T4, around 8 log CFU/ml during 21 days. During the entire storage period, the viability of both *B. animalis* and *L. rhamnosus* in beverages T1–T4 was always above the minimum recommended level 6 log CFU/g, suggested for beneficial health effects in the gut (Kongo et al., 2006; Salva et al., 2011). Moreover, the populations of both *B. animalis* and *L. rhamnosus* in the beverages were in accordance with the requisites of the Brazilian legislation, above 8–9 log CFU in their customarily consumed serving portion per eating occasion of a cup or 200 ml (ANVISA, 2003, 2008).

Kongo et al. (2006) produced a fermented goat milk using a mixed starter culture of *B. animalis* and *Lactobacillus acidophilus* in controlled conditions, which was stored for 10 days under refrigerated conditions (5–7 °C). From the second day to the end of storage, the pH conditions of that fermented goat milk (around 4.25–4.00) were similar to those found for the beverages in the present study. According to the authors, the viability of microorganisms remained stable within the evaluated period (above 7 log CFU/ml for *B. animalis* and around 8 log CFU/ml for *L. acidophilus*). Similarly to that was observed in the present study, Senaka Ranadheera et al. (2012) verified that the viability of *B. animalis* subsp. *lactis* BB-12 in stirred goat milk yogurts added with juice of mixed fruits (5–15 g/100 g) ranged from 8 (at day 0) to 7 log CFU/ml (after 4 weeks) during the storage at 4 °C, with pH values from, approximately, 4.30–4.10 in the same period. On the other hand, a lower viability was observed by Salva et al. (2011) for *L. rhamnosus* CRL 1505 (maximum 6–7 log CFU/ml) in fermented goat milks produced with *S. thermophilus* strains CRL806 and CRL728 as starter cultures.

It has been reported that the addition of fruit juices or pulps might be deleterious to the survivability of some species and strains of probiotic microorganisms in food products, particularly due to acidity and the presence of antimicrobial compounds (Buriti, Komatsu et al., 2007; do Espírito Santo et al., 2012; Vinderola et al., 2002). In the present study, however, it was verified that both *B. animalis* and *L. rhamnosus* maintained good viability in the presence of either guava or soursop pulps. In contrast, the use of dietary fibre ingredients has been considered beneficial to increase the viability of lactic acid bacteria during storage of products (do Espírito Santo et al., 2012); nonetheless the strains evaluated in this study were unable to metabolise the PHGM, since no significant difference ($P < 0.05$) between trials with and without this ingredient concerning the viability of these microorganisms was verified throughout the storage (Table 3). Similarly, the PHGM was not fermented under *in vitro* conditions by the same strains (*B. animalis* BB-12, *L. rhamnosus* Lr-32 and *S. thermophilus* TA 40) in a previous study (Buriti et al., 2014). On the other hand, some studies with the commercial partially hydrolysed galactomannan obtained from the guar gum suggest that bifidobacteria and lactobacilli possibly use this carbohydrate indirectly in the large intestine through fermentation of the oligosaccharides produced during the galactomannan degradation by the other bacterial groups in the human gut (Ohashi et al., 2012; Okubo et al., 1994). The stability of PHGM in the goat dairy beverages due to lack of fermentation by the starter and probiotic cultures was considered a good result, which assures that TDF content of products will remain high throughout the storage.

3.3. Instrumental texture of dairy beverages

The instrumental texture parameters of the dairy beverages are presented in Table 4. The firmness, consistency, cohesiveness and viscosity index of dairy beverages T1–T4 remained unchanged during the 21 days of storage and no significant difference was verified between the sampling periods for these products ($P > 0.05$). On the other hand, the overall mean of all instrumental texture parameters evaluated was significantly higher in beverages T3 and T4 containing PHGM ($P < 0.05$). Similarly to the present study, Brennan and Tudorica (2008) observed a significant increase in the apparent viscosity of low fat yogurts added of 2, 4 and 6 g/100 g of Sunfiber – a galactomannan ingredient obtained through partial hydrolysis of guar gum – compared with the control low fat yogurt, without the addition of this ingredient. According to the authors, the addition of 2 g/100 g Sunfiber in the low fat yogurts

Table 3
Viability of *S. thermophilus*, *B. animalis* and *L. rhamnosus* (mean ± SD)[a] in dairy beverages T1, T2, T3 and T4, after 1, 7, 14 and 21 days of storage at 4 ± 1 °C. See Table 1 for the description of the goat dairy beverages.

Microorganism	Time (days)	Trials			
		T1	T2	T3	T4
S. thermophilus (log CFU/ml)	1	9.12 ± 0.17^{B}	9.09 ± 0.11^{B}	9.12 ± 0.13^{B}	9.07 ± 0.15^{B}
	7	9.07 ± 0.14^{B}	8.94 ± 0.19^{B}	8.95 ± 0.18^{AB}	8.89 ± 0.14^{B}
	14	8.76 ± 0.28^{AB}	8.69 ± 0.22^{AB}	8.90 ± 0.19^{AB}	8.79 ± 0.21^{AB}
	21	8.59 ± 0.35^{A}	8.49 ± 0.42^{A}	8.66 ± 0.29^{A}	8.50 ± 0.38^{A}
B. animalis (log CFU/ml)	1	8.02 ± 0.12^{B}	7.96 ± 0.15^{C}	8.05 ± 0.08^{B}	7.94 ± 0.06^{B}
	7	7.71 ± 0.16^{B}	7.57 ± 0.23^{B}	7.71 ± 0.12^{B}	7.71 ± 0.17^{B}
	14	7.22 ± 0.16^{A}	7.13 ± 0.24^{A}	7.24 ± 0.25^{A}	7.18 ± 0.29^{A}
	21	7.00 ± 0.26^{A}	7.01 ± 0.30^{A}	7.01 ± 0.28^{A}	6.98 ± 0.28^{A}
L. rhamnosus (log CFU/ml)	1	8.07 ± 0.27^{A}	7.99 ± 0.20^{A}	8.11 ± 0.22^{A}	8.08 ± 0.24^{A}
	7	8.12 ± 0.28^{A}	8.14 ± 0.24^{A}	8.13 ± 0.23^{A}	8.14 ± 0.22^{A}
	14	8.12 ± 0.33^{A}	8.07 ± 0.26^{A}	8.23 ± 0.30^{A}	8.20 ± 0.27^{A}
	21	8.18 ± 0.28^{A}	8.06 ± 0.21^{A}	8.13 ± 0.28^{A}	8.14 ± 0.27^{A}

[A–D] The different superscript capital letters in a column for a same microorganism denote significant differences ($P < 0.05$) between sampling days. Trial effect was not significant ($P > 0.05$).

[a] Nine measurements (three batches, in triplicate, at each sampling day).

Table 4
Texture parameters (mean ± SD)[a] analysed for dairy beverages T1, T2, T3 and T4, after 7, 14 and 21 days of storage at 4 ± 1 °C. See Table 1 for the description of the goat dairy beverages.

Item	Time (days)	T1	T2	T3	T4
Firmness ($N \times 10^2$)	1	15.42 ± 1.05	14.95 ± 0.73	18.76 ± 1.06	18.58 ± 0.74
	7	15.44 ± 0.79	14.84 ± 0.65	18.78 ± 0.98	18.55 ± 0.42
	14	15.80 ± 1.01	14.80 ± 0.58	18.90 ± 0.87	18.31 ± 0.59
	21	15.43 ± 0.68	15.32 ± 0.90	19.15 ± 1.12	18.62 ± 1.08
	Overall mean	15.52 ± 0.85^{A}	14.98 ± 0.71^{A}	18.90 ± 0.95^{B}	18.51 ± 0.71^{B}
Consistency ($N \times 10^2$ s)	1	328.87 ± 28.93	312.03 ± 3.94	411.89 ± 39.88	406.06 ± 16.19
	7	330.30 ± 24.68	311.61 ± 7.38	404.13 ± 20.62	398.32 ± 16.35
	14	335.82 ± 30.27	311.25 ± 11.33	404.58 ± 16.95	398.10 ± 18.28
	21	329.73 ± 19.26	324.75 ± 13.97	406.82 ± 19.89	408.16 ± 27.13
	Overall mean	331.18 ± 24.53^{B}	314.91 ± 10.92^{A}	406.76 ± 20.94^{C}	402.66 ± 19.21^{C}
Cohesiveness[b] ($N \times 10^2$)	1	8.92 ± 0.80	8.92 ± 0.90	12.18 ± 0.57	12.06 ± 1.38
	7	8.81 ± 0.88	8.37 ± 0.50	12.02 ± 0.57	11.69 ± 0.50
	14	8.65 ± 0.37	8.79 ± 0.57	11.91 ± 0.74	11.86 ± 0.51
	21	8.65 ± 0.37	8.33 ± 0.48	12.36 ± 0.65	11.49 ± 0.48
	Overall mean	8.78 ± 0.74^{A}	8.60 ± 0.65^{A}	12.11 ± 0.62^{B}	11.77 ± 0.79^{B}
Viscosity index[b] ($N \times 10^2$ s)	1	9.68 ± 1.21	9.16 ± 0.54	21.27 ± 1.79	19.53 ± 3.49
	7	9.40 ± 1.24	8.67 ± 0.93	19.41 ± 1.51	17.94 ± 2.06
	14	9.65 ± 1.52	8.75 ± 1.07	18.97 ± 1.16	18.49 ± 1.73
	21	10.21 ± 1.21	9.05 ± 0.71	18.39 ± 1.25	17.17 ± 1.63
	Overall mean	9.73 ± 1.25^{A}	8.91 ± 0.81^{A}	19.49 ± 1.73^{C}	18.28 ± 2.36^{B}

$^{A–C}$ The different superscript capital letters in a same row denote significant differences ($P < 0.05$) between trials. Time effect was not significant ($P > 0.05$).
[a] Six measurements (three batches, in duplicate, at each sampling day).
[b] Absolute values of cohesiveness and viscosity index.

resulted in an apparent viscosity comparable with the control full fat yogurt sample. Additionally, the low fat yogurts containing 4 and 6 g/100 g Sunfiber were significantly more viscous than the full fat yogurt.

Particularly in relation to consistency, the dairy beverage T2 produced only with soursop presented the lowest values, differing significantly from the other trials concerning this parameter ($P < 0.05$). Although the mean composition of the beverages T1 and T2 was similar (Table 2), without significant differences ($P > 0.05$), some polysaccharides with gelling properties, such as pectin, are present in lower proportion in soursop pulp rather than in guava pulp, which might contribute for the significant lower consistency in T2 compared to T1. Ramírez and Pacheco de Delahaye (2009) observed 10.99 g/100 g and 8.91 g/100 g soluble dietary fibre in the dry matter of flours produced with the edible portions of guava and soursop fruits, respectively. Moreover, Mahattanatawee et al. (2006) found 1.04 g/100 g pectin in the whole edible parts of red guavas (Sardina cultivar). On the other hand, the pectin content in soursop (Crioula cultivar) was at least two-fold lower during the post-harvest ripening period, which ranged from 0.2 g/100 g to 0.5 g/100 g, according to de Lima et al. (2006). In the present study, the dairy beverage T3, with addition of guava pulp and PHGM, presented the highest viscosity index and differed significantly from other trials ($P < 0.05$), probably due to an additive effect of these two ingredients on its viscosity.

3.4. Sensory evaluation of dairy beverages

The results of the sensory evaluation of the dairy beverages are shown in Table 5. The sensory parameters evaluated (flavour, texture, appearance, colour and overall acceptability) remained unchanged throughout the storage of trials T1–T4 and no

Table 5
Sensory evaluation scores (mean ± SD of 30 observations) obtained for dairy beverages T1, T2, T3 and T4, after 7, 14 and 21 days of storage at 4 ± 1 °C. See Table 1 for the description of the goat dairy beverages.

Item	Time (days)	T1	T2	T3	T4
Flavour	7	8.19 ± 1.64	6.24 ± 2.65	8.38 ± 1.96	7.86 ± 2.05
	14	8.04 ± 1.60	7.03 ± 2.28	8.20 ± 1.62	7.75 ± 1.70
	21	7.84 ± 1.65	7.02 ± 2.03	8.63 ± 1.53	8.02 ± 2.01
	Overall mean	8.02 ± 1.62^{B}	6.78 ± 2.33^{A}	8.41 ± 1.70^{B}	7.88 ± 1.91^{B}
Texture	7	6.79 ± 2.57	5.94 ± 2.35	8.95 ± 1.39	8.58 ± 1.21
	14	6.97 ± 1.71	6.34 ± 2.03	8.44 ± 1.31	8.46 ± 1.39
	21	7.41 ± 1.72	6.41 ± 1.93	8.71 ± 1.36	8.25 ± 2.01
	Overall mean	7.06 ± 2.03^{B}	6.23 ± 2.10^{A}	8.70 ± 1.36^{C}	8.43 ± 1.57^{C}
Appearance	7	8.07 ± 1.70	7.20 ± 2.04	8.75 ± 1.24	8.13 ± 1.50
	14	7.88 ± 1.51	7.22 ± 2.20	8.61 ± 1.17	7.91 ± 1.62
	21	8.30 ± 1.17	7.20 ± 1.50	8.69 ± 1.26	7.91 ± 1.67
	Overall mean	8.09 ± 1.47^{B}	7.20 ± 1.91^{A}	8.68 ± 1.21^{C}	7.98 ± 1.58^{B}
Colour	7	8.44 ± 1.65	7.34 ± 2.19	8.78 ± 1.12	8.30 ± 1.39
	14	7.77 ± 1.81	7.40 ± 2.21	8.42 ± 1.28	7.76 ± 1.89
	21	8.24 ± 1.64	7.81 ± 1.50	8.58 ± 1.48	8.04 ± 1.52
	Overall mean	8.15 ± 1.70^{AB}	7.53 ± 1.98^{A}	8.59 ± 1.30^{B}	8.04 ± 1.61^{AB}
Overall acceptability	7	7.96 ± 1.32	6.56 ± 2.32	8.58 ± 1.25	8.14 ± 1.77
	14	7.77 ± 1.53	6.72 ± 2.23	8.16 ± 1.41	7.98 ± 1.40
	21	8.19 ± 1.12	7.24 ± 1.49	8.73 ± 1.09	7.92 ± 2.03
	Overall mean	7.98 ± 1.32^{B}	6.85 ± 2.04^{A}	8.50 ± 1.26^{C}	8.01 ± 1.74^{BC}

$^{A–C}$ The different superscript capital letters in a same row denote significant differences ($P < 0.05$) between trials. Time effect was not significant ($P > 0.05$).

significant differences between the sampling periods were detected ($P > 0.05$). In general, dairy beverage T2 (soursop) received the lowest scores for all sensory attributes. On the other hand, the highest scores were given for trial T3 (guava plus PHGM). Moreover, the presence of PHGM improved the sensory features of trials T3 and T4 compared to their respective samples T1 and T2, without this ingredient.

Beverage T2 differed significantly ($P < 0.05$) from other trials concerning the scores of flavour. The number of evaluations about flavour of T2 as "disliked most" was increased, particularly due to its acidic taste, according to the consumers' opinion (data not shown). As discussed previously, beverage T2 presented higher titratable acidity ($P < 0.05$) in relation to the other trials (Table 2), and therefore, this parameter influenced negatively its flavour. However, despite the increased titratable acidity of beverage T4 compared to T1 and T3 ($P < 0.05$), the scores of flavour did not differed significantly between these trials ($P > 0.05$), possibly due to a "masking effect" of PHGM over the taste of T4. According to Gallardo-Escamilla et al. (2007), the higher viscosity caused by certain polysaccharides might result in the reduction of flavour and taste perception of foods. The authors verified that the addition of 0.16 g/100 g carboxymethyl cellulose or 0.32 g/100 g propylene glycol alginate in fermented rennet whey (both trials with viscosity of 25 mPa s) reduced significantly the acid taste perception in comparison with the control ($P < 0.05$).

The addition of PHGM enhanced the texture of dairy beverages, since trials T3 and T4 presented scores significantly higher than T1 and T2 for this attribute ($P < 0.05$). The number of evaluations about texture of T1 and T2 as "liked most" was reduced, since that, according to the consumers' opinion, these trials were perceived as "fluid", while beverages T3 and T4 were perceived as "creamy" (data not shown). Moreover, the scores of texture for trial T2 were significantly reduced in comparison with T1 ($P < 0.05$) probably due to a lower concentration of pectin and other soluble polysaccharides in the soursop pulp than in guava pulp (de Lima et al. 2006; Mahattanatawee et al., 2006; Ramírez & Pacheco de Delahaye, 2009). These results were in agreement with the data obtained by instrumental texture.

Beverage T3 received the highest scores for appearance among the trials ($P < 0.05$), and the scores for beverage T4 were higher compared to T2 ($P < 0.05$). According to these results, the addition of PHGM improved the appearance of guava and soursop beverages, which probably is associated with the positive changes also conferred by PHGM concerning texture.

The addition of PHGM did not result in differences in the scores of colour of beverages T3 and T4 compared with respective trials T1 and T2, in which this ingredient was absent ($P > 0.05$).

For the overall acceptability, beverage T2 received the lowest scores and the scores for beverage T3 were significantly higher compared with T1 ($P < 0.05$). As a result of the improvement in texture and appearance, the addition of PHGM in the production of dairy beverages T3 and T4 contributed for a significant increase of their overall acceptability in comparison with respective trials T1 and T2 ($P < 0.05$).

4. Conclusions

The dairy beverages processed with goat milk, goat cheese whey, guava or soursop pulps, and with or without PHGM showed to be good vehicles for the probiotics *B. animalis* subsp. *lactis* BB-12 and *L. rhamnosus* Lr-32. The variables tested in the present study (addition of guava or soursop pulps and the presence or absence of PHGM) did not influence the viability of the starter and probiotic microorganisms during the storage period. Nonetheless, the higher acidity negatively affected the flavour of the beverage produced with only soursop pulp, and the addition of PHGM together with soursop pulp improved flavour acceptability. The addition of PHGM to the dairy beverages increased their dietary fibre content and affected positively the instrumental texture and sensory features of guava and soursop dairy beverages, especially concerning texture, appearance, and overall acceptability. Based on these results, the PHGM might be recommended to improve nutritional and sensory quality of fermented probiotic beverages produced with goat milk and cheese whey.

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