academicJournals

Vol. 14(2), pp. 149-155, 14 January, 2015
DOI: 10.5897/AJB2014.14208
Article Number: A94C4CC49624
ISSN 1684-5315

http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Physicochemical and sensory profile of yogurt added with passion fruit peel flour

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Received 25 September, 2014; Accepted 22 December, 2014

Yogurt is a type of fermented milk with high nutritional value. The addition of passion fruit peel flour to yogurt may help the retention of water due to the presence of starch, in addition to being a source of nutrients and fiber. Thus, the aim of this study was to evaluate the physicochemical parameters, color and sensory profile of yogurt added with passion fruit peel flour. Four yogurt formulations with concentrations of 0% (control) 0.10, 0.15 and 0.20% passion fruit peel flour were processed. Scanning electron microscopy (SEM) showed irregular particles with the presence of starch granules. With higher additions of passion fruit peel flour to yogurts, a proportional increase of titratable acidity, water holding capacity and viscosity were observed. The addition of passion fruit peel flour modified the colors parameters of yogurt, tending to yellow and red due to the presence of carotenoids in passion fruit peel flour. In the sensory profile, highest concordance coefficient (CC) and means were assigned to texture of no passion fruit peel flour yogurt, and lowest CC and means were attributed to the flavor of yogurt with 0.20% passion fruit peel flour. The addition of passion fruit peel flour resulted in yogurts with better texture and higher water retention capacity, thus reducing syneresis.

Key words: Fermented milk, passion fruit peel flour, syneresis, color, Scanning electron microscopy (SEM).

INTRODUCTION

Dairy products have great nutritional value and they are considered source of proteins, carbohydrates, fats and minerals, which are fundamental for the body development. Yogurt is a product obtained by milk fermentation. In Brazil, dairy product industries that produce yogurt have grown considerably, mainly due to economic stability and increased consumer demand (Oliveira et al., 2013).

According to the Brazilian legislation (Normative Instruction No. 46 of October 23th, 2007), yogurts are products obtained by coagulation and pH decrease of milk or reconstituted milk, with other dairy products or

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Table 1. Nutritional information of passion fruit peel flour portion to 15 g.

Quantity	Serving size	% DV*
Energy value	14 kcal = 596kJ	1
Carbohydrates	2.6 g	1
Proteins	1 g	1
Total fat	0 g	0
Saturated fats	0 g	0
Trans fats	0 g	**
Monounsaturated fats	0 g	**
Polyunsaturated fats	0 g	**
Dietary fiber	6 g	24
Sodium	5 mg	0

*% Daily Values are based on a diet of 2000 kcal or 8400 kJ. The daily values may be higher or lower depending on energy needs. ** DV not established.

food substances added or not of through fermentation by *Streptococcus salivarius* subsp*. Thermophilus*e, *Lactobacillus delbruechii* subsp*. bulgaricus*, or other lactic acid bacteria, which contributes to the final characteristics of the product (Brazil, 2011).

The association of satiety and health and well-being promotion highlights the growing demand for products with functionality; the market for foods aimed at specific health benefits is promising, leading to an increasing number of studies in the area of milk-derived foods such as yogurt, a product of high biological value, beneficial health properties and easy marketing (Santana et al., 2012).

Passion fruit peel flour with potential for use in the enrichment of products, represents around 60% of the fruit weight, which makes the amount of processing waste very expressive; thus, the use of this byproduct obtained in the food industry has shown an increasing interest due to the possibility of economic exploitation and ecological contribution (Cardoso et al., 2013).

The flour of passion fruit peel besides being rich in fibers (Centenaro et al., 2004), has the ability to decrease cholesterol and blood glucose levels and provide the proper functioning of the gastrointestinal system (Cordova et al., 2005).

Aiming to offer a product with more desirable characteristics, with appropriate texture and reduced syneresis, this study evaluated the addition of passion fruit peel flour to yogurt and determined the physicochemical parameters, color and sensory profile.

MATERIALS AND METHODS

Passion fruit peel flour

The passion fruit peel flour was obtained in establishment of the city Rio Verde, Goiás state, Brazil. Table 1 contains the nutritional information of flour passion fruit peel (15 g).

Passion fruit peel flour microscopy was performed at the Laboratory of High Resolution Microscopy, Universidade Federal de Goiás, Goiânia Campus, Brazil, using scanning electron microscope (Jeol®, JSM – 6610), equipped with EDS, Thermo Scientific NSS Spectral Imaging.

Yogurt

To perform the study, refrigerated milk was aseptically collected from the Dairy Cattle Sector of the Instituto Federal Goiano - Rio Verde Campus, Brazil.

Yogurt was processed at the Laboratory of Animal Products. The milk was filtered in order to remove any physical contamination.

Each treatment consisted of 5 L of milk with 10% sucrose added; the mixture was subsequently submitted to heat treatment, and pasteurization was done at temperature of 90°C for a period of three minutes. After pasteurization, the temperature of samples was reduced to 42°C and starter culture mixture (non-commercial cultivation lactic developed in laboratory) was added.

For inoculation, 10% of plain yogurt was used as inoculum; samples were incubated in incubator (BOD Quimis ® Model Q-315D) at temperature of 42°C for about 4 h or until pH reached 4.5.

After clotting, the incubator temperature was adjusted to 20°C, and when samples reached 20°C, the clot was broken using a glass rod in circular motion for one minute.

In preliminary studies, it was observed that the addition of passion fruit peel flour before heat treatment caused casein instability preventing coagulation. Therefore, passion fruit peel flour was added after breaking the clot.

Four yogurt formulations with added passion fruit peel flour were developed: Treatment 1 - yogurt formulation without the addition of passion fruit peel flour (control), Treatment 2 – Yogurt with added 0.10% passion fruit peel flour; Treatment 3 - Yogurt with added 0.15% passion fruit peel flour; Treatment 4 – Yogurt with added 0.20% passion fruit peel flour. Each treatment consisted of three replicates according to Table 2.

After the addition of passion fruit peel flour, yogurt samples were packaged in aseptic polypropylene containers (20 pots of 250 mL per treatment). They were identified, exposed in a laminar flow UV chamber (30 to 45 min), before filling at the same UV chamber. Finally, the yogurts were sent for refrigeration (7°C) and physicochemical analyses, color and evaluation of sensory parameters were performed every seven days for 28 days (four weeks).

Physical and chemical analysis

About 10 g of yogurt were weighed and three drops of 1% phenolphthalein solution added, and titrated with a 0.1 N sodium hydroxide solution until the appearance of persistent pink color for about 30 s (Brazil, 2006).

pH Meter Model W38 (Bel Engineering ®) was used to evaluate pH. Reading was performed after homogenization. Three points in each pot were analyzed, corresponding to the three replicates of each treatment.

Yogurts at temperature of 7°C were submitted to analysis in triplicate of apparent viscosity determined using Quimis ® viscometer with speed of 30 rpm (revolutions per minute). The results were expressed in mPa.s (Mili Pascal per second).

To determine syneresis in three trials, 30 g of yogurt was distributed on filter paper on the top of a funnel, and after five hours of drainage, the liquid volume was collected and the syneresis rate was calculated (Riener et al., 2010).

The water holding capacity (WHC) was determined in triplicate (Parnell-Clunies et al., 1986), being expressed as percentage (%) through adapted methodology according to the following

Table 2. Formulations of plain yogurt with the addition of passion fruit peel flour.

Ingredient	Treatment			
	1 (Control)	2	3	4
Whole milk (L)	5.00	5.00	5.00	5.00
Sucrose (%)	10.00	10.00	10.00	10.00
Passion fruit peel flour (%)	-	0.10	0.15	0.20
Starter culture (%)	10.00	10.00	10.00	10.00

equation:

$$WHC\ (\%) = \frac{100 \text{ x initial sample weight } - \text{ supernatant weight}}{\text{sample weight}}$$

Sedimentation was assessed in three trials according to the method described by White et al. (2008). Instrumental color parameters (L *, a * and b *) of yogurt samples were analyzed in triplicate in Hunter Lab Colorimeter Model Color Quest II, Laboratory of Physicochemical Analyses, School of Food Engineering, Universidade Federal Goiás, Goiânia, GO, Brazil (Hunterlab, 1998).

The sensory characteristics (visual and characteristic flavor) were assessed in order to quantify the consumer preference for different types of yogurts with added passion fruit peel flour, as well as the purchase intent.

Analyses were performed using 50 untrained panelists. The only inclusion criterion was the acceptance of the participant to perform the sensory analysis, agreeing to taste and express their satisfaction with the product analyzed.

Four yogurt formulations without passion fruit peel flour (control) and with the addition of 0.10, 0.15 and 0.20% passion fruit peel flour were evaluated.

The model adopted for sensory analysis was the acceptance test, and the sensory evaluation was based on scores assigned by tasters through a 9-point hedonic scale, in which flavor, aroma, texture and color of yogurt were assessed. Along with the overall appearance of the product, the purchase intent of panelists on each of sample was assessed using a 5-point hedonic scale (Ali, 2005).

The analysis was performed in individual booths at the Laboratory of Sensory Analysis, Federal Institute Goiano - Rio Verde Campus, Brazil. The four samples were coded with three-digit numbers and presented under white light in white cups of 50 mL to each panelist. The amount of yogurt served was the same, about 20 mL, aiming not to influence consumer's opinion.

Samples were presented to panelists at about 6°C in a balanced and random manner so that the three samples will appeared the same number of times in a given position.

Sensory analysis we authorized by the ethics committee in research involving human beings of Instituto Federal de Educação, Ciência e Tecnologia Goiano - IF Goiano, under protocol of number: 020/2013.

Statistical analyses

Statistical analysis of instrumental color parameters was performed using the ASSISTAT software (Silva and Azevedo, 2009), with four treatments; three replicates per treatment. Means were compared by the Tukey test at 5 and 1% probability in a fully randomized design. The average results of pH, titratable acidity, syneresis, water holding capacity, sensory profile and purchase intent were also evaluated through ASSISTAT software (Silva and Azevedo, 2009). Means were compared by the Tukey test at 5% probability. Coefficient of concordance was calculated according to Silva et al. (2010).

RESULTS AND DISCUSSION

The external morphology of passion fruit peel flour after evaluation of the physical structure by scanning electron microscopy (SEM) is shown in Figure 1.

With 30 X magnification, passion fruit peel flour presented several particles of irregular shapes as seen in image (Figure 1A). With 300 X magnification, the composition was diversified and interspersed with small groups or clusters of polyhedral shape (Figure 1B). With 1,400 X magnification, the arrangement of fibrous filamentary compounds could be observed (Figure 1C). With 5,000 X magnification, particulate cells were observed in the presence starch of circular shape bounded to fragmented walls (Leonel et al., 2009).

Figure 1D shows starch granules: similar structures (Vieira et al., 2010), with micrographs of cassava starch granules ranging from 15 µm to 4 mm. Table 3 shows the mean values of luminosity (L *), chromaticity a * and chromaticity b * parameters, determined in the four types of yogurts with added passion fruit peel flour after eight days of storage at 5°C, where L * ranged from 0 (black) to 100 (white), a * from red (+ a *) to green (-a *) and b * from yellow (+ b *) to blue (-b *). With regard to the L color parameter, no change was observed with the addition of passion fruit peel flour.

When assessing the chromaticity (a *), treatment 4 with added 0.20% passion fruit peel flour presented value closer to zero (-0.76) demonstrating higher proximity to red, with significant difference ($p > 0.05$) from treatment 1 (control).

Treatment 1 (control) showed the lowest chromaticity value, indicating greater tendency to green, confirming that the addition of passion fruit peel flour directly influenced color, tending to red. Treatments 2 and 3 show no significant difference ($p < 0.05$) compared to the other treatments.

In relation to chromaticity (b *) values, treatment 1 (control) showed the lowest value 7.04, with less tendency to yellow, showing significant difference ($p < 0.01$) from treatments 3 and 4 and similarity with treatment 2.

Treatments 3 and 4 with yogurts with higher percentage of passion fruit peel flour showed the highest b * values (more yellow) of 8.63 and 8.68, respectively. Treatment 2 did not differ ($p < 0.01$) from the other treatments.

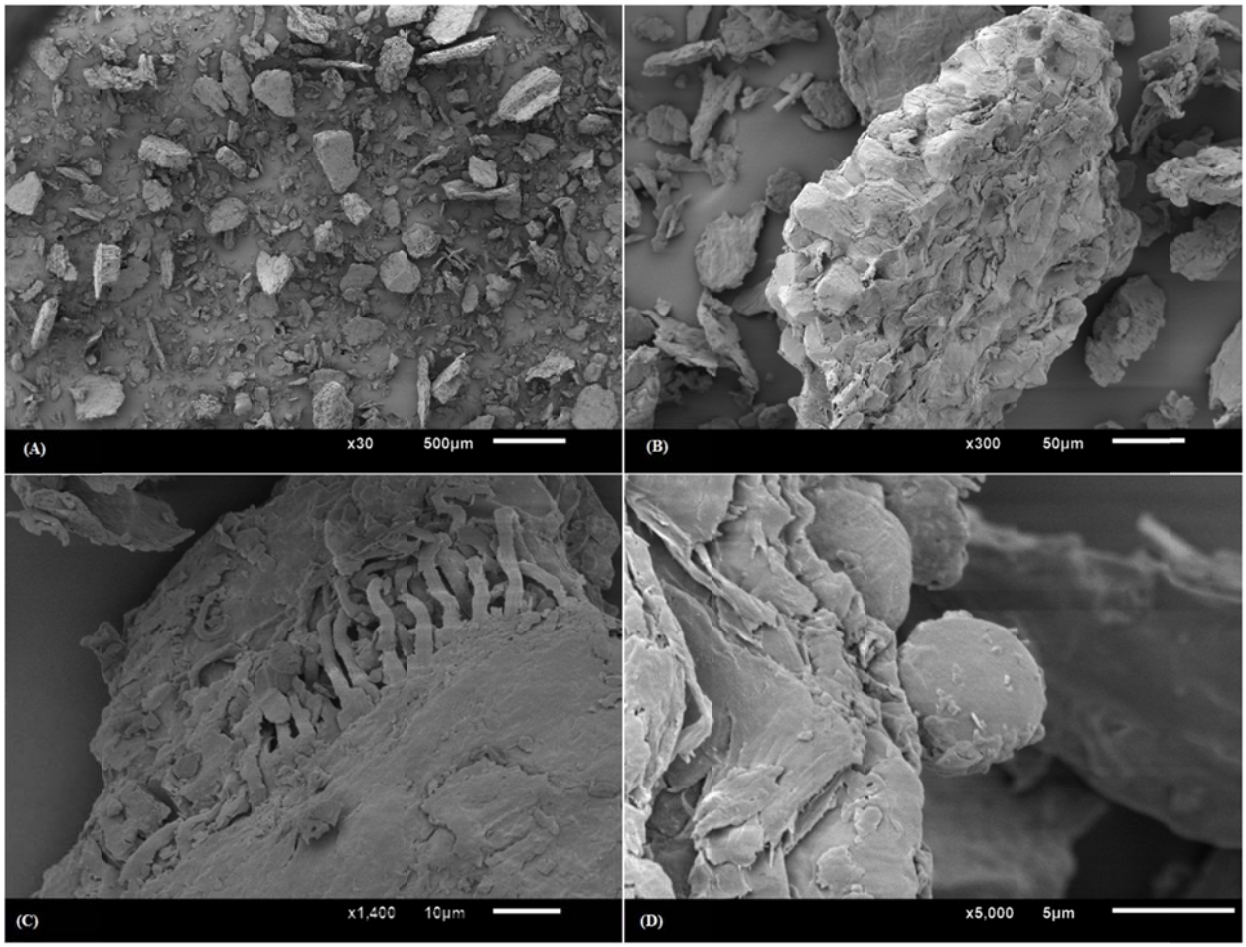

Figure 1. Scanning electron microscopy images of passion fruit peel flour added to yogurt.

Table 3. Mean values of color parameters of yogurts with increasing levels of passion fruit peel flour after eight days of storage at 5°C.

Passion fruit peel flour (%)	Parameter		
	L[1]	a[1]	b[1]
0	81.08[b]	-1.60[b]	7.04[b]
0.10	82.37[a]	-1.28[ab]	7.99[ab]
0.15	80.90[b]	-0.97[ab]	8.63[a]
0.20	81.57[ab]	-0.76[a]	8.68[a]
RSD	1.21	39.38	14.44
p-value	0.0031[2]	0.0399[3]	0.0039[2]

[1] L* ranges from 0 (black) to 100 (white), a* ranges from red (+ a *) to green (-a *) and b* ranges from yellow (+ b *) to blue (-b *); [2] different letters in the column differ significantly at 5% probability; [3]different letters in the column differ significantly at 1% level of probability.

Fruits of passion fruit are rich in various types of carotenoids (Souza et al., 2004). The tendency of colors to yellow and red are justified by the presence of carotenoids, which besides being natural dyes present in passion fruit, have antioxidant power with protective action against cardiovascular diseases and cancer (Rodrigues et al., 2013).

In the evaluation of probiotic yogurt with inulin-type fructans of different degrees of polymerization, the results are similar, trending to red and yellow, and it is noteworthy that although to the naked eye, natural yogurts are visually white and bright, the sensitivity of the colorimeter is capable of detecting with accuracy the slightly reddish yellow color of yogurts (Pimentel et al., 2012).

The results presented in this study indicate that the addition of passion fruit peel flour is a source of color variation in yogurts and can interfere with the purchasing decisions of consumers.

The titratable acidity mean, pH, syneresis and water holding capacity values of yogurts with increasing addition of passion fruit peel flour (Table 4) are presented by the mean test Tukey, at 5% probability. The data for these parameters did not fit to quadratic models and linear regressions during storage for 29 days.

It was observed that when passion fruit peel flour was added to yogurt, the mean acidity values were higher,

Table 4. Average results of titratable acidity, pH, syneresis and water holding capacity (WHC) of plain yogurt enriched with passion fruit peel flour during 28 days of storage.

Passion fruit peel flour	Titratable acidity (g of lactic acid/100 g)	pH	Syneresis (%)	WHC (%)
0%	0.79[b]	4.29[a]	45.62[a]	54.38[c]
0.10%	0.86[a]	4.20[a]	43.67[b]	56.33[b]
0.15%	0.86[a]	4.06[b]	39.64[c]	60.36[a]
0.20%	0.82[b]	4.08[b]	37.80[c]	62.20[a]
RSD	12.88	3.48	10.78	7.71
p-value	0.0054	0.0000	0.0000	0.0000

Means followed by different letters in the column differ significantly by Tukey test at 1 % probability.

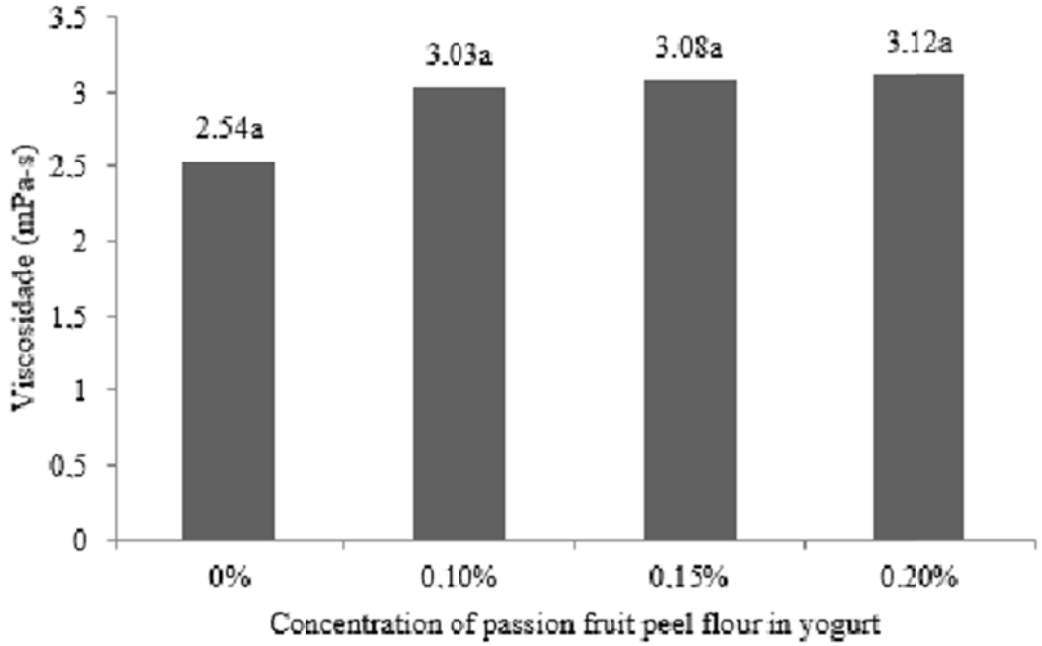

Figure 2. Analysis of viscosity of yogurt with increasing passion fruit peels flour levels.

and consequently greater decrease in pH values were also observed. Continuous production of lactic acid by lactic acid bacteria is common in yogurts, making them more acidic during storage (Ribeiro et al., 2011).

The pH values of treatments 1 and 2, without addition of passion fruit peel flour and with addition of 0.10% passion fruit peel flour, respectively, showed no significant difference ($p > 0.05$) and were similar to each other (Castro et al., 2013).

Syneresis was higher in treatments 1 and 2 (45.62 and 43.67%, respectively), with significant difference ($p > 0.05$) between them, which is reflected in higher WHC values of yogurts of Treatments 3 and 4. Spontaneous syneresis is the result of the natural shrinkage of gel and is associated with instability of the protein network, which loses the ability to bind to the aqueous phase of the product (Lucey, 2002).

The sedimentation values were zero, that is, there was no sedimentation in any of the treatments during the storage of yogurt samples for 72 h at 5°C. Figure 2 shows the average viscosity values of plain yogurt added of passion fruit peel flour determined at 30 rpm (revolutions per minute) during the 8 days of storage. The highest viscosity values observed, although showing no significant difference ($p > 0.05$) in the statistical analysis, were related to treatments 2, 3 and 4, that is, in treatments with added passion fruit peel flour, the viscosity values were 3 03, 3.08 and 3.12 mPa-s, respectively. Yogurt without passion fruit peel flour showed the lowest viscosity value.

Table 5. Mean and coefficient of concordance between tasters (CC) in the sensory analysis of yogurt enriched with passion fruit peel flour for parameters flavor, aroma, appearance and color.

Sensory parameters	Concentration of passion fruit peel flour in yogurts			
	0%	0.10%	0.15%	0.20%
Color	6.68[a]	6.70[a]	6.70[a]	6.88[a]
CC	30.9%	30.17%	32.47%	33.69%
Aroma	6.74[a]	7.02[a]	6.94[a]	6.76 a
CC	30.9%	32.33%	34.35%	30.76%
Flavor	7.14[a]	6.96[ab]	6.42[ab]	6.22[b]
CC	35.89%	31.19%	28.32%	29.10%
Texture	7.18[a]	7.12[a]	6.72[a]	6.68[a]
CC	36.26%	34.74%	29.87%	26.84%
Purchase intention	3.78[a]	3.76[a]	3.42[a]	3.46[a]
CC	35.07%	29.33%	27.75%	17.17%

Different letters in the row differ significantly by the Tukey test at 5 % probability.

The addition of passion fruit peel flour can contribute to the increase of the viscosity of yogurts and therefore, it could be inferred that the higher the addition of flour passion fruit peel, the higher the viscosity values.

The consistency and viscosity of yogurts are main factors influencing the quality of the final product, thus greatly influencing its acceptance (Mathias et al., 2013). Table 5 shows the average values of the sensory parameters color, aroma, flavor, texture and purchase intent, as well as the coefficient of concordance between tasters (CC) determined in the four types of yogurts added of passion fruit peel flour after eight days of storage.

The concordance coefficient between the tasters corresponded to percentage of tasters who agreed to the average allocated for each sensory parameter. In assessing the color parameters, the concordance between tasters was higher for treatment 4 (33.69%), followed by treatments 3, 1 and 2, but no significant difference ($p > 0.05$) between treatments was found in the Tukey test.

Although no significant difference was observed for aroma results, the highest average was observed for treatment 2 (7.02), corresponding to "liked moderately". However, the concordance between tasters was higher for Treatment 3 (34.35%), followed by treatments 2, 1 and 4.

The concordance between tasters for flavor was higher for treatment 1 (35.89 %), with a significant difference ($p > 0.05$) from treatment 4. Treatments 2 and 3 did not differ significantly ($p > 0.05$) from other treatments.

Cakes enriched with passion fruit peel flour also had lower flavor acceptance for treatment with the highest percentage of passion fruit peel flour, which is due to the bitter aftertaste in the product with the proportions of ingredients used (Miranda et al., 2013).

Regarding parameter texture, no significant difference ($p > 0.05$) between averages was observed, and the concordance between tasters was higher for Treatment 1 (36.26 %), followed by treatments 2, 3 and 4.

Regarding purchase intent, no significant difference ($p > 0.05$) between averages was observed, and the concordance between tasters was higher for treatment 1 (35.07 %), followed by treatments 2, 3 and 4.

Purchase intent showed values from 3.42 to 3.78, results that guarantee a possible purchase of the yogurt. Santana et al. (2012), during sensory analysis evaluation of pitaya-based yogurt enriched with quinoa and sucralose, obtained good acceptance and purchase intent, which values are very close to those shown in the present study (Santana et al., 2012).

These results indicate that the tasters although have not preferred one yogurt with the addition of flour passion fruit peel, purchase intent is not affected, which may be a prebiotic of concern in future studies; the addition of passion fruit peel flour is a great contribution to the improvement of yogurts.

Conclusion

The addition of passion fruit peel flour resulted in yogurt with increased viscosity, improved texture and higher water retention capacity, higher concentration of passion fruit peel flour resulted in lower values of syneresis, therefore yogurts are more acceptable because syneresis is undesirable by consumers.

The addition of passion fruit peel flour in yogurt intensified the color and aroma, but flavor, texture and purchase intent were higher in yogurt without the addition of passion fruit peel flour.

Further studies should be carried out to establish the best levels of addition of passion fruit peel flour and the association with this prebiotic fruit pulp in order to improve

acceptance and sensory characteristics.

Conflict of Interests

The author(s) have not declared any conflict of interests.

ACKNOWLEDGEMENTS

Capes, CNPq and FAPEG are acknowledged for the financial support.

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