CHAPTER 11

Yogurt with passion fruit (*Passiflora edulis*) pulp and pectin added: effects on the viability of probiotic bacteria and on physicochemical, rheological and sensory properties

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ABSTRACT

This study aimed to evaluate the viability of probiotic cultures (Lactobacillus acidophilus, Bifidobacterium lactis) and their physicochemical, rheological, and sensory properties in yogurt with passion fruit pulp and pectin. Six treatments of yogurts were prepared, differing in the addition of passion fruit pulp and pectin and different combinations of starter and probiotic cultures. The addition of passion fruit pulp and pectin interfered in pH, acidity, syneresis, and viscosity but did not affect the viability of the probiotic cultures, and in the sensory evaluation, the evaluators accepted the yogurt well. The results obtained were promising, as in addition to the antioxidant potential and significant nutritional value, they allow the development of a new dairy product with the insertion of regional fruits.

Keywords: Lactic acid bacteria, Functional food, Dairy food, Fruits, Fermented milk.

1 INTRODUCTION

The growing demand for foods that bring health benefits has been driving the market for functional foods that, according to a report by Grand View Research Inc., should reach US $ 275.77 billion by 2025 (GVR, 2019). As part of the functional food group, probiotics are defined as live microorganisms that, when administered in adequate quantities, can benefit the consumer's health (WHO/FAO, 2001; Hill et al., 2014).

Among the broad benefits, the consumption of probiotics favors the maintenance of a healthy intestinal microbiota (Zhang et al., 2018), boosts antagonistic action against pathogenic microorganisms through the production of metabolites and/or competition for nutrients and action site (Sotoudegan et al., 2019; Tsiouris and Tisiouris, 2016), stimulates and regulates the innate and adaptive immune response (Di Cerbo et al., 2016; Mishra and Mishra, 2018) and neutralizes toxic products (Sotoudegan et al., 2019).

The most commonly used as probiotics microorganisms belong to the genus *Lactobacillus* spp., classified as lactic acid bacteria (LAB) and *Bifidobacterium* spp. (Vitheejongjaroen et al., 2021).

Yogurt is considered a suitable product for supplementing probiotic bacteria and a vehicle for delivery to their site of action in the intestine. It is commonly produced by fermenting cow's milk using LAB, *Lactobacillus bulgaricus,* and *Streptococcus thermophilus*, under controlled temperature and environmental conditions, which will cause the pH to fall, followed by protein denaturation, providing the product's sensory characteristics (Hutkins, 2008).

Adding sweeteners, fruits or fruit jelly in yogurts contributes to the generation of new products and also serves to mask the high acidity that is essential when it comes to acceptability by most consumers (Das et al., 2019). In this context, adding passion fruit to yogurt is an alternative option since Brazil is emerging as the world's largest producer, representing almost 70% of global production, with an annual production of around 700,000 tons (IBGE, 2021).

As for its nutritional characteristics, passion fruit pulp has a significant amount of β-carotene, riboflavin, niacin, calcium, phosphorus and ascorbic acid and low-fat content, highlighting that among the different species, there are variations in the content of phenols and antioxidant capacity. Another fraction of the fruit that draws attention is its peel, as it has protein content and, more importantly, large amounts of dietary fiber, mainly pectin, which can represent 60 to 80% of the total weight (Fonseca et al., 2022).

Studies demonstrate that the administration of passion fruit pulp and peel influenced the reduction of blood pressure in hypertensive patients (Lewis et al., 2013), the reduction of cholesterol and triglycerides levels in HIV patients (Marques et al., 2016), insulin sensitivity (Balthar et al., 2021) and had neuroprotective effects (Tal et al., 2016).

Therefore, the present study aimed to evaluate the viability of probiotic cultures (*Lactobacillus acidophilus*, *Bifidobacterium lactis*) and their physicochemical, rheological, and sensory properties in yogurt with passion fruit pulp and pectin.

2 MATERIAL AND METHODS

2.1 MATERIAL

The bacteria used were YOG FVV 21 (*Streptococcus thermophilus*/*Lactobacillus bulgaricus*), PRO LAFTI L10 (*Lactobacillus acidophilus*), PRO LAFTI B94 (*Bifidobacterium lactis* B94) from Global Food® and ABT7 (*Bifidobacterium lactis* Bb-12/*Lactobacillus acidophilus*/*Streptococcus thermophilus*) from Chr. Hansen®.

To prepare the yogurt, UHT whole milk (Danby®, Brazil), sucrose (União®, Brazil), and passion fruit from the cultivar BRS Ouro Vermelho (EC-2-O) (Pelotas, RS, Brazil) were used.

2.2 EXPERIMENTAL DESIGN

In total, six treatments were developed, and the experimental design (Table 1) was completely randomized (DIC), with factorial arrangement (3x2), two treatments and three combinations of cultures, six types of products, and each product was prepared in three replications, totaling 18 experimental units to be evaluated.

Table 1. Design to evaluate the effect of passion fruit pulp and pectin (PPP) on the viability of different probiotics and the physicochemical, rheological, and sensory properties of yogurt

Bacteria	**Treatment / codes**	**Passion fruit pulp and pectin (PPP)**
St + Lb	Y	-
Y + La + Bl 94	LABL	-
St + Bb-12 + La	SBLA	-
St + Lb	YM	+
Y + La + Bl 94	LABLM	+
St + Bb-12 + La	SBLAM	+

(-) no addition of passion fruit pulp and pectin; (+) with the addition of passion fruit pulp and pectin; St + Lb: *Streptococcus thermophiles/Lactobacillus bulgaricus*; Y + La + Bl 94: *Streptococcus thermophiles/Lactobacillus bulgaricus/Lactobacillus acidophilus/Bifidobacterium lactis* B94; St + Bb-12 + La: *Streptococcus thermophilus/Bifidobacterium lactis* Bb-12/*Lactobacillus acidophilus*

2.3 CULTURE PREPARATION

The lyophilized cultures were dissolved in UHT milk (Nestlé®, Switzerland), as recommended by the manufacturers and stored at -80 ºC for later use.

2.4 PASSION FRUIT PULP AND PECTIN PREPARATION

The fruits were washed and sanitized, and the seeds were separated through a sieve (32 Mesh). Next, the following were evaluated: pH, soluble solids content expressed in °Brix (AOAC, 2006), antioxidant activity by the DPPH method (Brand-Williams et al., 1995), and colorimetric test using the CIEL*a*b* system (Minolta Chromameter, CR–300, Japan). The pulp was put into polyethylene bottles and frozen at -18 °C.

Pectin was obtained by removing the flavedo from the peel (yellow), leaving the albedo (white), which was cut into thin strips and taken to an oven (45 °C/18 h). The dehydrated albedo was crushed in a Hammer mill (Laboratory Mill 3100/Perten instruments), stored in sterile plastic polyethylene bags, and wrapped in aluminum foil, under refrigeration (~ 5 °C).

2.5 YOGURT PRODUCTION

The yogurt base was prepared using UHT milk with 10% (w/v) sucrose added. It underwent heat treatment of 90 ºC/5 min and was then cooled to 37 ºC and 42 ºC (according to treatment) to inoculate the microorganisms.

After homogenization, the milk was deposited in sterile containers and then incubated at 37 ºC and 42 ºC until reaching pH 4.6. The samples were then stored at refrigeration temperature, the coagulum was broken, and three treatments received pulp and flour from the passion fruit peel (pectin), 6% (w/w), data and 0.1% (w/w) were added respectively and then stored at ~ 5 °C for 21 days. Preliminary tests were carried out to determine the contents of sugar, pulp and passion fruit pectin (PPP) for the yogurt formulation (data not shown).

2.6 PHYSICOCHEMICAL AND RHEOLOGICAL ANALYSIS

At 0, 7, 14, and 21 days of product storage, an analysis of titratable acidity and pH (AOAC, 2006) was performed. After 21 days of storage of products under refrigeration, analyses were performed of protein, fat, ash, moisture (AOAC, 2006), antioxidant activity (Brand-Williams et al., 1995), syneresis (Farnsworth et al., 2006), and viscosity (Haak rheometer, RS 150, in a rotary module, at 25 °C).

2.7 MICROBIOLOGICAL ANALYSIS

The presence of *Salmonella* spp. and counts of *Staphylococcus* coagulase-positive and molds and yeasts as recommended by Brazilian legislation (Brazil, 2022) were performed at 14 days of storage (APHA, 2002).

The cultures were counted at 0, 7, 14, and 21 days of product storage, through serial dilutions and selective agar plating, these being LP-MRS (Man Rogosa & Sharpe agar, with 0.2% lithium chloride and 0.3% sodium propionate) for *B. lactis* incubated at 37 °C/72 h/anaerobiosis, MRS bile agar (0.2% bile salts) for *L. acidophilus* incubated at 37 °C/72 h/aerobiosis, agar ST for *S. thermophilus* incubated at 30 °C/48 h/aerobiosis (Zacarchenco and Massaguer-Roig, 2004), and MRS agar for *L. bulgaricus* incubated at 30 °C/48 h/aerobiosis (APHA, 2002).

2.8 SENSORY EVALUATION

The LABLM treatment was chosen to proceed with the sensory analysis at 21 days of product storage through the acceptability test with 75 untrained tasters, using a structured 9-point hedonic scale (ISO, 2014) to judge the product ranging from 'like very much' to 'dislike very much'.

The study was approved by the Ethics Committee in Research with Human Beings of the Faculty of Dentistry of UFPel/Brazil, under registration n° 225/2011.

2.9 STATISTICAL ANALYSIS

The data were evaluated for normality by the Shapiro-Wilk test and the homogeneity of variance by the Hartley test. Afterward, the data were submitted to analysis of variance (ANOVA), and, in the case of a significant difference, the qualitative treatment factors with two levels were compared by the t-test ($p < 0.05$). A confidence interval of 95% probability was used for quantitative treatment factor.

3 RESULTS

3.1 CHARACTERIZATION OF PASSION FRUIT PULP

The pulp sample showed pH = 3.14, soluble solids content of 10.03 °Brix, and colorimetric profile for red = +0.87 and yellow = +23.41. The results showed that the content of soluble solids expressed in °Brix is just below the value established by Brazilian legislation (Brazil, 2018), 11 °Brix, and pH above 2.7.

Regarding the colorimetric profile, the positive values of a + and b + indicated a color tending towards red and yellow, indicating that the fruit was ripe. The value of antioxidant activity was 44.15 μmol g^{-1}.

3.2 YOGURT PRODUCTION

Table 2 shows the total fermentation time, incubation temperature, and percentage of starter and probiotic bacteria added to the yogurt treatments.

Table 2. Concentration of starter and probiotic bacteria, incubation temperature, and fermentation time in the preparation of the yogurt treatments

Treatment	**Concentration of starter and probiotic bacteria (0.2%)**	**Incubation temperature (°C)**	**Fermentation time (hours)**
Y	(St + Lb)	42	5.28
***YM**	(St + Lb)	42	5.30
LABL	(St + Lb) + (Bl 94 + La)	37	5.00
***LABLM**	(St + Lb) + (Bl 94 + La)	37	5.02
SBLA	(St) + (Bb-12) + (La)	37	4.45
***SBLAM**	(St) + (Bb-12) + (La)	37	4.46

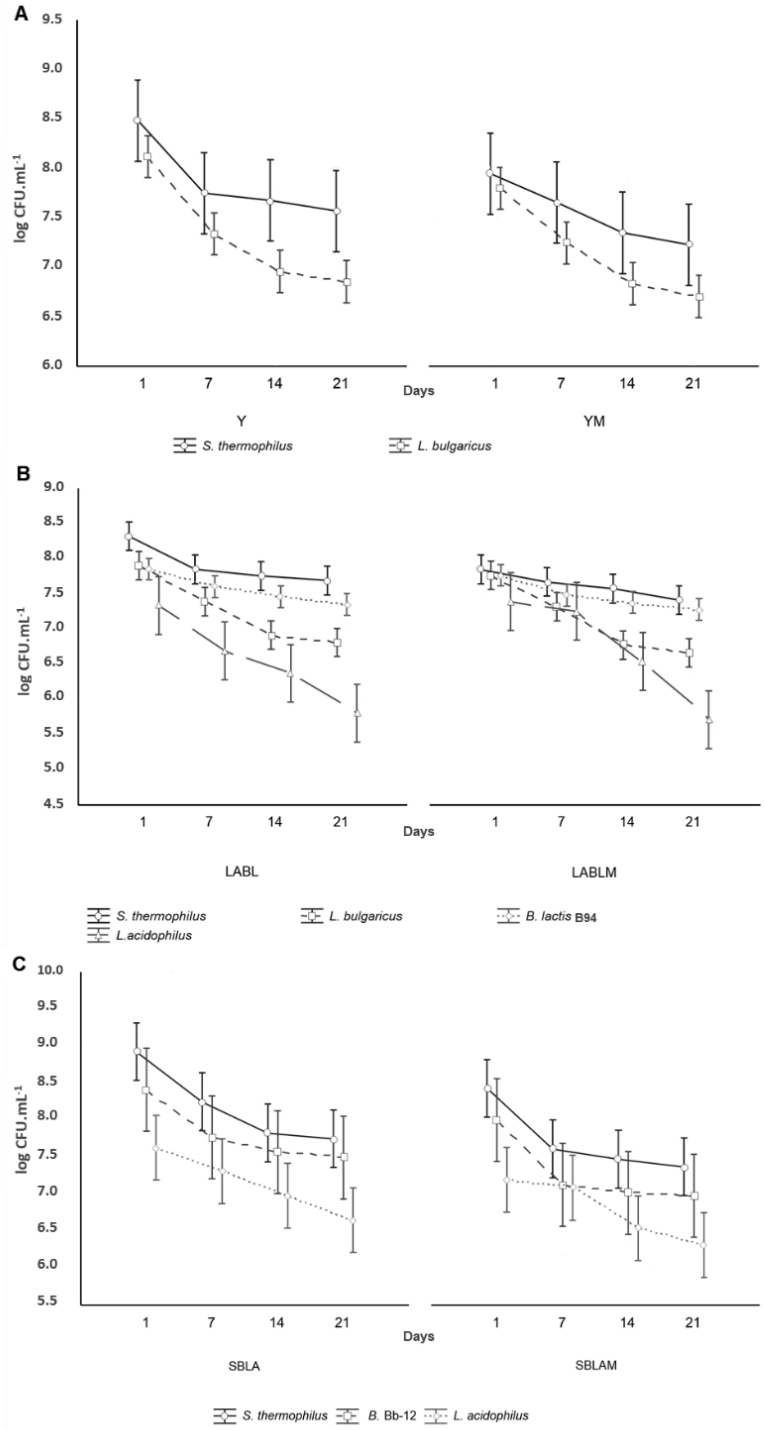
St: *S. thermophilus*; Lb: *L. bulgaricus*; Bb-12: *Bifidobacterium lactis* Bb-12; La: *L. acidophilus*; Bl 94: *B. lactis* B94; * with the addition of passion fruit pulp and pectin (PPP)

It is noted that in yogurts containing probiotic bacteria (LABL, LABLM, SBLA, and SBLAM), the average fermentation time was shorter when compared to yogurt that had only starter bacteria (Y and YM).

3.3 MICROBIOLOGICAL ANALYSIS

The average counts for starter and probiotic bacteria in their respective yogurt treatments from the 1st to the 21st day of storage can be seen in Figures 1A, 1B, and 1C.

Figure 1. Counts of starter and probiotic bacteria in Y and YM (A), LABL and LABLM (B), and SBLA and SBLAM (C) yogurts during 21 days of refrigerated storage



As for the addition of PPP, a significant difference was observed in all samples (Y *vs.* YM, p = 0.0148; LABL *vs.* LABLM, p = 0.0109; and SBLA *vs.* SBLAM, p = 0.0261), suggesting that the viability of the starter cultures was benefited by the addition of the treatments, a factor also observed in the Y and YM preparations when the yogurt supplementation was correlated with the storage time ($p = 0.0359$).

However, regarding the total storage period, significant reductions in the viability of *S. thermophilus* and *L. bulgaricus* were observed between treatments Y and YM ($p = 0.0020$), LABL and LABLM ($p = 0.0060$), and SBLA and SBLAM ($p = 0.0149$), indicating that the addition of probiotic microorganisms in the LABL and SBLA preparations with and without PPP did not help in the viability of the starter bacteria, as they presented reduction values greater than preparations Y and YM.

Regarding the viability of the probiotic *B. lactis* B94 and *L. acidophilus* (LABL and LABLM), no significant difference was verified in the yogurts during the study. The probiotic *B. lactis* 94 showed satisfactory growth, with counts around 7 log CFU mL^{-1} throughout the period; however, *L. acidophilus* was considered the least stable culture among the probiotics in both treatments, reducing about two cycles of logarithms (~ 5.8 log CFU mL^{-1}) in 21 days of storage. In the treatments SBLA and SBLAM, no significant difference was observed in the viability of the two probiotic microorganisms (Bb-12 and *L. acidophilus*).

Among all the probiotic bacteria added, both in yogurt with added PPP and in the product without PPP, the culture Bb-12 (SBLA and SBLAM) showed the highest viability until the 21st day of analysis (7.49 and 6.98 log CFU mL^{-1}, respectively), with counts higher than 6 log CFU mL^{-1}.

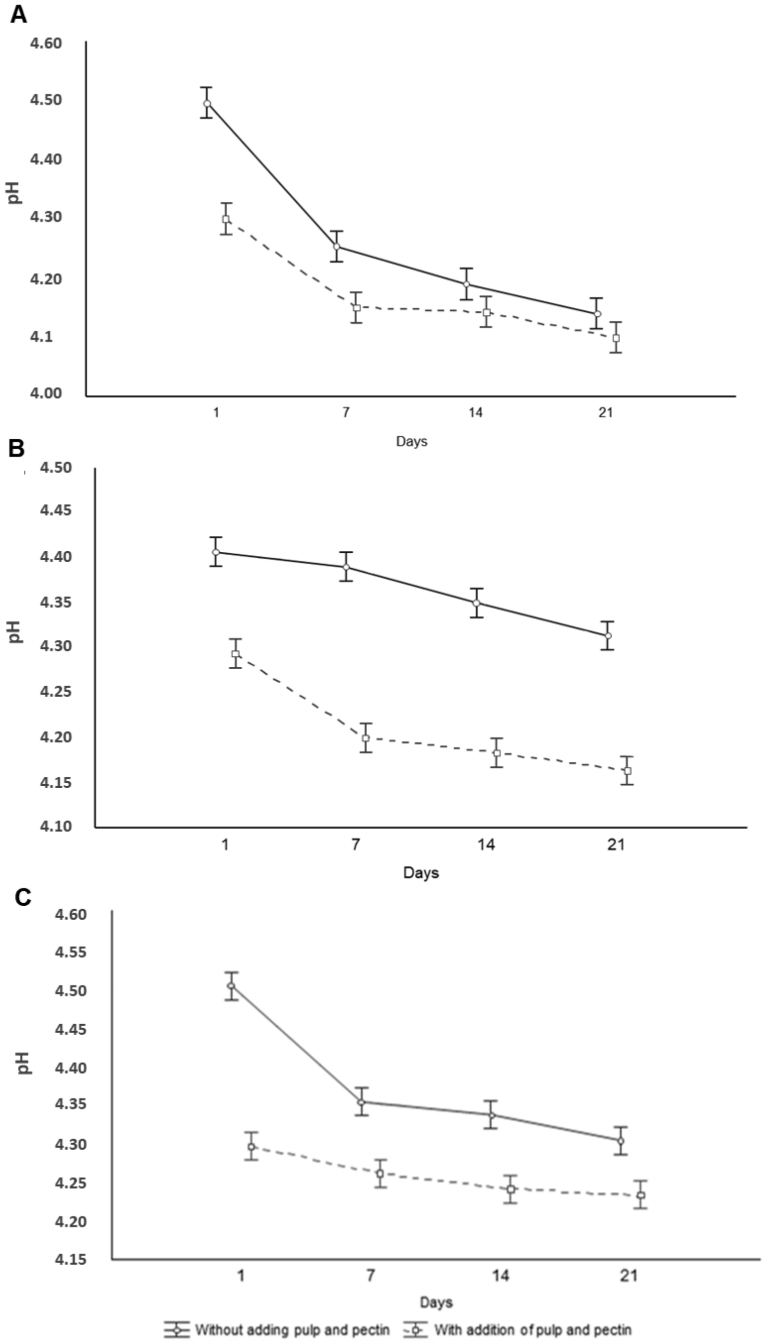
Because of the results obtained, the addition of PPP to yogurt did not affect the viability of probiotic bacteria during 21 days of storage under refrigeration.

Regarding microbiological quality, the SBLAM yogurt treatment showed satisfactory results, according to the microbiological parameters established by Brazilian legislation (Brazil, 2022), enabling us to assess the microbiological safety aspect of the product prior to sensory analysis.

3.4 PH VALUES AND ACIDITY (°D)

In Figure 2, the average pH values of Y and YM (2A), LABL and LABLM (2B), and SBLA and SBALM (2C) yogurts can be observed in the 21 days of storage.

Figure 2. Average pH values of Y and YM (A), LABL and LABLM (B), SBLA and SBLAM (C) yogurts during 21 days of refrigerated storage



In the present study, it was found that there was a significant difference in the pH and acidity values of all yogurts during the storage period ($p < 0.0001$).

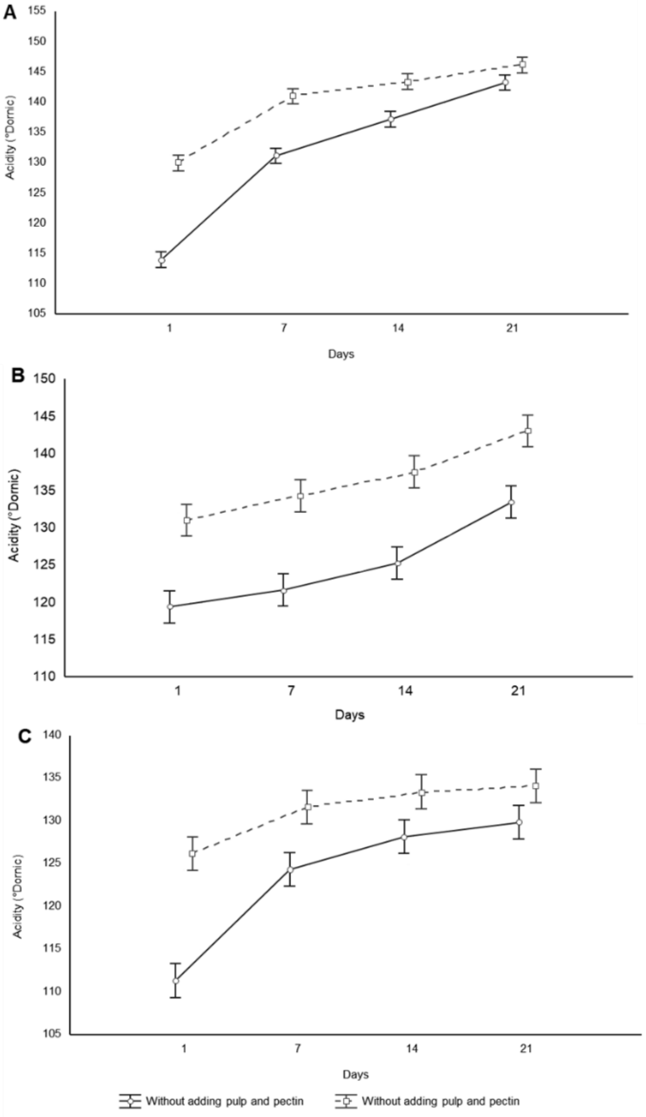
The pH values showed significant differences between the 1st and 7th day of storage in the Y *vs.* YM samples ($p = 0.0001$) and throughout the storage period in the LABL *vs.* LABLM ($p = 0.0001$) and SBLA *vs.* SBLAM samples ($p < 0.001$), showing similar behavior in all yogurts that contained PPP, with lower pH values in these products.

The LABLM yogurt showed the lowest pH (4.16) and the LABL the highest (4.31) among the probiotic yogurts. However, the last day of analysis presented pH values of at least 4.00.

Regarding the acidity content, significant differences were found in yogurts without the addition of PPP (Y, LABLA, and SBLA) to the samples with addition (YM, LABLAM, and SBLAM) on the 1st, 7th, and 14th days of storage ($p < 0.001$).

The average acidity values in Dornic degrees (°D) of Y and YM (3A), LABL and LABLM (3B), and SBLA and SBALM (3C) yogurts in the 21 days of storage can be seen in Figure 3.

Figure 3. Values of acidity expressed in Dornic degrees (°D) of yogurts Y and YM (A), LABL and LABLM (B), and SBLA and SBLAM (C) during 21 days of storage under refrigeration



As the major product of bacterial fermentation of carbohydrates, lactic acid is primarily responsible for increased acidity in fermented milk (Parada et al., 2007; Chen et al., 2017). At the end of the 21 days, yogurt YM had the highest acidity (146.17 °D), but among the probiotic yogurts, LABLM was the yogurt with the highest (143.00 °D) and SBLA with the lowest acidity (129.8 °D).

When comparing the pH and acidity values obtained at the end of fermentation with those obtained during storage, it was found that there was a decrease in pH value and an increase in acidity during storage in all yogurts due to the continuous production of acids by LAB. These values were of greater significance in the yogurts that included the addition of PPP. Similar results were not observed by Santo et al. (2012) and Senadeera et al. (2018), whose control yogurts showed lower total acidity values than those added with fruit extracts of passion fruit and anona, respectively.

3.5 PHYSICOCHEMICAL AND RHEOLOGICAL CHARACTERIZATION

The average values of protein, moisture, fat, and ash of the yogurts evaluated on the 21st day of storage are shown in Table 3.

Table 3. Percentage (%) values of protein, moisture, ash, and fat in yogurt after 21 days of storage under refrigeration

Yogurt	**Protein**	**Fat**	**Moisture**	**Ash**
Y	2.61 ± 0.01	3.05 ± 0.04	77 ± 0.01	0.81 ± 0.00
YM	2.63 ± 0.02	3.00 ± 0.03	75 ± 0.01	0.83 ± 0.01
LABL	2.77 ± 0.01	3.10 ± 0.03	78 ± 0.00	0.82 ± 0.02
LABLM	2.79 ± 0.04	3.20 ± 0.01	77 ± 0.03	0.80 ± 0.03
SBLA	2.73 ± 0.01	3.04 ± 0.01	74 ± 0.01	0.81 ± 0.00
SBLAM	2.72 ± 0.03	3.06 ± 0.02	79 ± 0.02	0.79 ± 0.01

There were no significant differences in the antioxidant activity of yogurts with (YM, LABLM, SBLAM) and without (Y, LABL, SBLA) the addition of PPP, on the 21st day of storage under refrigeration, ranging from ~ 10 to 6 μmol g^{-1} equivalent to Trolox, respectively. Therefore, adding 6% passion fruit pulp did not influence maintaining a high antioxidant activity in yogurt compared to *in natura* pulp (44.15 μmol g^{-1}).

By determining the viscosity, all yogurt samples analyzed had, as expected, non-Newtonian behavior, and the results can be seen in Table 4.

Table 4. Average viscosity values of yogurt samples at 15 ºC, expressed in mPa s^{-1} at different shear rates

Sample	**Shear rate**			
	10 s^{-1}	**30 s^{-1}**	**60 s^{-1}**	**100 s^{-1}**
Y	172 ± 0.10	116 ± 0.02	129 ± 0.11	123 ± 0.02
YM	80.5 ± 0.08	57 ± 0.14	67.3 ± 0.08	94.3 ± 0.05
LABL	260 ± 0.03	236 ± 0.10	218 ± 0.05	179 ± 0.03
LABLM	252 ± 0.07	169 ± 0.12	106 ± 0.11	71.3 ± 0.13
SBLA	474 ± 0.06	382 ± 0.02	262 ± 0.09	186 ± 0.12
SBLAM	229 ± 0.11	159 ± 0.03	67.7 ± 0.12	51.0 ± 0.09

The SBLA yogurt was the most viscous or consistent in all shear rates. The SBLAM, LABLM, and LABL treatments had equivalent viscosities at the rate of 10 s^{-1}, corresponding to the second highest viscosity in this shear. However, they had different behavior with increased viscosity. In the YM sample, the lowest viscosity was found in all the shear rates analyzed.

The variations in the syneresis profile of yogurts, depending on the addition or not of PPP and the combinations of probiotic bacteria, presented the following percentage values: Y = 16.4%, YM =

17.3%, LABL = 9.7%, LABLM = 11.3%, SBLA = 14.8%, and SBLAM = 16.7%. It was found that there was a significant difference ($p = 0.0180$) between YM yogurt and LABL yogurt on the 21st day of storage. It can be inferred that the YM yogurt's syneresis index is higher than the LABL yogurt, which means that LABL presented significantly higher serum retention capacity, as it presented lower syneresis indexes.

3.6 SENSORY EVALUATION

The tasters attributed SBLAM yogurt values of color, aroma, flavor, consistency and overall impression. It was found that the consistency significantly differed between the global impression ($p = 0.0143$), flavor ($p = 0.0064$), and color ($p = 0.0393$) attributes.

The average values of the grades corresponded to moderately liked /very much liked, with flavor being the sensory attribute with the highest average (7.99), followed by global impression (7.95), color (7.89), aroma (7.71), and consistency (7.41) were the sensory attributes with less acceptance attributed by the tasters.

The SBLAM was considered an acceptable product, with an acceptability index greater than 70%. Therefore, the yogurt with PPP made with probiotic cultures was well accepted by the tasters and has market potential.

4 DISCUSSION

In the present study, the values of antioxidant activity were similar to those found by Jáuregui et al. (2007), for *P. mollisima* (41.18 µmol g^{-1}) and lower than those found by Vasco et al. (2008), 70 µmol g^{-1}. The pulp of *P. edulis* contains citric and malic acids as the primary organic acids, in addition to compounds that exert antioxidant action, such as cis-resveratrol, naringenin, kaempferol-3-glucoside, myricetin and procyanidin-B1 (Santos et al., 2021).

As for the production of yogurt, in a study carried out by Mani-López et al. (2014), when comparing the reduction in the fermentation time of fermented yogurt only plus the starter bacteria with the yogurt and added probiotic bacteria, a decrease of 30 minutes was observed. In the present study, the reduction in the fermentation time was 26 minutes for yogurt with probiotic bacteria added. This variation is justified because each LAB has different capacities to grow and ferment milk. Other researchers have reported that probiotic bacteria perform poorly in milk acidification when compared to starter cultures (Donkor et al., 2007; Damin et al., 2008).

According to a study by Shori *et al.* (2022), different types of yogurt were fermented by *S. thermophilus*/*L. delbrueckii* subsp. *lactis* (control), and by *S. thermophilus*/*L. rhamnosus*/*L. married*/*L. plantarum* as co-cultures, at 21 days in all treatments, *S. thermophilus* showed counts greater than 8.04 log CFU mL^{-1} in the control yogurt, and higher counts were observed in the other yogurts, indicating that the addition of probiotic cultures may have favored the development of *S. thermophilus*, promoting symbiosis, a behavior also observed in the present study.

However, it is worth mentioning that there is a consensus that probiotic foods must have a concentration of probiotic bacteria greater than 6 log CFU mL^{-1} of the product at the time of consumption so that the benefits attributed to the strain are conferred to the consumer (Papadopoulou et al., 2018).

Mani-López et al. (2014) observed decreased pH values during storage due to post-acidification, and yogurt with *S. thermophilus*/*L. bulgaricus* and yogurt fermented by *S. thermophilus*/*L. bulgaricus*/*L. acidophilus,* the pH ranged from 4.5 to 4.3, data that corroborate those found in the present study.

When comparing the pH and acidity values obtained at the end of fermentation with those obtained during storage, it was found that there was a decrease in pH value and an increase in acidity during storage in all yogurts due to the continuous production of acids by LAB. These values were of greater significance in the yogurts that included the addition of PPP. Similar results were not observed by Santo et al. (2012) and Senadeera et al. (2018), whose control yogurts showed lower total acidity values than those added with fruit extracts of passion fruit and anona, respectively.

The results on the composition of the formulations indicate that the treatments with the addition of PPP influenced the protein and fat contents. Differences in the protein and fat content of yogurt may result from the raw material and ingredients used and/or be related to the proteolytic and lipolytic activity of the microorganisms, data evidenced by Shori et al. (2022), who observed higher protein values in yogurts with the addition of vegetable extracts, and Lopes et al. (2022), who identified more elevated levels of protein, fat and ash in cupuaçu and golden flaxseed yogurt.

In yogurt flavored with prickly pear jelly, the antioxidant activity remained high after adding jelly to dairy, with a 72.7 µmol Trolox g^{-1} (Silva et al., 2021). However, in this experiment, the antioxidant potential was evaluated after 21 days, which may have influenced the degradation of compounds.

The SBLAM, LABLM, YM, and Y treatments were initially the most pseudoplastic; that is, they had the most significant decrease in viscosity with the increase in shear stress (Jabarkhyl et al., 2020); however, except for SBLAM and LABLM, they did not maintain this behavior with the increase in the shear rate. The LABL, on the other hand, had the lowest pseudoplasticity, and although SBLA did not have the greatest pseudoplasticity, it maintained this behavior throughout the analyzed shear range, which is important, since the shear range in question simulates what occurs during chewing and swallowing. In the treatment YM, in the interval between the rates of 30 and 100 s^{-1}, there was an undesirable dilating behavior when the viscosity increased with the increase of the shear stress (Jabarkhyl et al., 2020). The influence of pseudoplasticity on the sensory qualities of the product is related to the reduction of viscosity during chewing, decreasing the sensation of gumminess, and allowing a better perception of flavor (Morell et al., 2014), characteristics that enhance the acceptance of the product. Thus, the SBLA yogurt presented the most desirable results. Different technological factors influence the rheological properties of yogurts, such as (a) factors involved during the preparation of the milk base and its heat treatment, (b) incubation temperature and type of culture used, and (c) cooling process (Lee and Lucey, 2010).

It was observed that all the treatments with added PPP presented lower values of viscosity. According to Uenojo and Pastore (2007), one of the changes that can be observed in products made from fruit is texture. This change is usually caused by the action of hydrolytic enzymes in pectin, especially pectin esterase.

The physical properties of yogurt, including syneresis, play an essential role in product quality and consumer acceptance. Whey separation of on the product surface is considered the primary defect in yogurt production of (Gyawali et al., 2016).

Concerning the sensorial analysis, adding fruits can increase the sugar content in the yogurt, provoking greater acceptance by the consumer. Şengül et al. (2012) also observed the highest score for the overall aspect of acceptability for yogurt containing cherry pulp.

5 CONCLUSION

It was concluded that the addition of passion fruit pulp and pectin did not significantly influence the viability of probiotic cultures *L. acidophilus* and *B. lactis* (> 6 log CFU mL^{-1}), independent of being combined with the starter cultures. Still, this addition significantly affected yogurt's pH, acidity, viscosity, and syneresis. Regarding the antioxidant activity, more than 6% passion fruit pulp was needed to maintain high activity in the product. The product was sensorial and well accepted by consumers, with flavor being the attribute with the highest average.

The development of a new yogurt, a dairy derivative already consumed by a large part of the population, in addition to providing the consumer with a functional product and significant nutritional value, also allows full use of regional fruits.

HIGHLIGHTS

- Passion fruit pulp and pectin were able to increase the nutritional value.
- The formulation of the product influenced the rheological characteristics.
- The yogurt formulation did not influence the viability of microorganisms.
- The yogurt with the insertion of regional fruits showed market potential.

CONFLICT OF INTEREST

The authors confirm that they have no conflicts of interest with respect to the work described in this manuscript.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All participants signed an informed consent form (TCLE) according to the guidelines established and approved by the Ethics Committee in Research with Human Beings of the Faculty of Dentistry of UFPel/Brazil.

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