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Petit Suisse cheese added açai: characterization and effect of the use of thickeners

Queijo *Petit Suisse* adicionado de açaí: caracterização e efeito do uso de espessantes

Queso *Petit Suisse* añadido de açaí: caracterización y efecto del uso de espesantes

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Abstract
The search for the development of new dairy products has been growing in recent years. *Petit Suisse* is a cheese that has been standing out in Brazil, reaching expansion in the market. The cheese added by fruits, such as açai (*Euterpe oleracea* Mart.), enhances the energy and nutritional value of the product. Its texture is an important feature, influencing the acquisition by the public. Thus, the objective was to develop and analyze the texture and physicochemical parameters of *Petit Suisse* cheeses added with açai. Three formulations (F_1, F_2 and F_3) were prepared with different thickeners (xanthan gum and gelatin) and analyzed for texture, moisture, protein and pH parameters. The results indicated similarity between the different formulations for the texture parameters: F_1 and F_3 showed no significant difference ($p \geq 0.05$), and F_2 differed from F_3 only in elasticity and cohesiveness. It was concluded that the application of different thickeners in Petit Suisse influenced its quality, being considered the best formulation that contained the mixture of thickeners (F_3).
Keywords: Gelatin; Xanthan gum; Lactose; Dairy products.

Resumo
A busca pelo desenvolvimento de novos produtos lácteos vem crescendo nos últimos anos. *Petit Suisse* é um queijo que vem se destacando no Brasil, alcançando expansão no mercado. O queijo com adição de frutas, como o açaí (*Euterpe oleracea* Mart.), potencializa o valor energético e nutricional do produto. Sua textura é uma característica importante, influenciando na aquisição pelo público. Assim, objetivou-se desenvolver e analisar a textura e os parâmetros físico-químicos de queijos *Petit Suisse* adicionado de açaí. Três formulações (F_1, F_2 e F_3) foram preparadas com diferentes espessantes (goma xantana e gelatina) e analisadas quanto aos parâmetros de textura, umidade, proteína e pH. Os resultados indicaram similaridade entre as diferentes formulações para os parâmetros de textura: F_1 e F_3 não apresentaram diferença significativa ($p \geq 0,05$), e F_2 diferiu de F_3 apenas em elasticidade e coesividade. Concluiu-se que a aplicação de diferentes espessantes no Petit Suisse influenciou sua qualidade, sendo considerada a melhor formulação que continha a mistura de espessantes (F_3).
Palavras-chave: Gelatina; Goma xantana; Lactose; Produtos lácteos.

Resumen
La búsqueda por el desarrollo de nuevos productos lácteos ha ido creciendo en los últimos años. El *Petit Suisse* es un queso que viene destacándose en Brasil, alcanzando expansión en el mercado. El queso con la adición de frutas, como el açaí (*Euterpe oleracea* Mart.), aumenta el valor energético y nutricional del producto. Su textura es una característica importante, que influye en la adquisición por parte del público. Así, el objetivo fue desarrollar y analizar la textura y los parámetros fisicoquímicos de quesos *Petit Suisse* adicionados con açaí. Se prepararon tres

formulaciones (F_1, F_2 y F_3) con diferentes espesantes (goma xantana y gelatina) y se analizaron los parámetros de textura, humedad, proteína y pH. Los resultados indicaron similitud entre las diferentes formulaciones para los parámetros de textura: F_1 y F_3 no mostraron diferencia significativa ($p \geq 0.05$), y F_2 difería de F_3 solo en elasticidad y cohesividad. Se concluyó que la aplicación de diferentes espesantes en Petit Suisse influyó en su calidad, siendo considerada la mejor formulación la que contenía la mezcla de espesantes (F_3).
Palabras clave: Gelatina; Goma xantana; Lactosa; Productos lacteos.

1. Introduction

The dairy market has a wide variety of processed products. The *Petit Suisse* cheese has expanded in the national market, being the fifth most produced cheese in the Brazil (Torres et al., 2020). This cheese is obtained from *quark* cheese, through the fermentation of milk by the action of mesophilic culture (Lactococcus lactis subsp. lactis, Lactococcus lactis subsp. cremoris) or thermophilic culture (Streptococcus thermophilus) (Deolindo et al., 2019).

Petit-Suisse is a fresh cheese – unripened, unsalted, soft, creamy, with a texture comparable to thick yogurt. It has been consumed all over the world being among the most popular French soft cheeses (Esmerino et al., 2015). In Brazil, *Petiti suisse* cheese is often combined with fruits, usually consumed as a dessert and intended for children, although it is well accepted by all age groups and has great potential for innovation (Lopes et al., 2018; Torres et al., 2020; Barcelos et al., 2020; Rezende, 2021). Bermudez-Beltrán et al. (2020) produced a *Petit Suisse* cheese added with cape gooseberry and supplemented with moringa leaf powder and gelatin, through 3 formulations: control (F_1); product with 3% gelatin (F_2); and product with 3% gelatin and 2% moringa (F_3). The authors observed in the study that the product F_3 (with gelatin and moringa) had higher nutritional value. However, sensory acceptance was significantly modified after moringa leaf powder was incorporated into the product formulation. Rezende et al. (2021) elaborated a *Petit Suisse* with the addition of green banana biomass. The physicochemical analyzes showed that the product met the standards of the legislation for this cheese. The product presented a content of high averages of sensorial acceptance, concluding that the final product has a high market potential and may be another alternative for healthy eating.

Among the fruits that can be added to fresh cheeses, açai has been widely used, mainly in the development of dairy products, such as yogurt, fermented milk, ice cream and desserts (Campos et al., 2017; Matias et al., 2014; Vasconcelos et al., 2014). Açai is the fruit of the açaizeiro (*Euterpe oleracea* Mart.), it contains a high content of anthocyanins, responsible for its functional functions, in addition to presenting a high energy value. In addition, açai has attracted the attention of the food and pharmaceutical market in recent decades, for presenting several bioactive properties, such as antioxidants, analgesics, neuroprotective and anti-inflammatory effects (Costa et al., 2018; Borges et al., 2021; Barbosa & Carvalho Junior, 2022). In the research by Santo et al. (2010) açai pulp was added to milk used in yogurt production to assess the fatty acid profile and viability of probiotic bacteria. The authors observed that the açai yoghurts had a higher content of polyunsaturated fatty acids, and that the addition of açai favored the increase in *Lactobacillus acidophilus*, *Bifidobacterium animalis* subsp. *lactis* and *Bifidobacterium longum*.

A very important characteristic of cheeses is texture, directly influencing their acceptance. (Souza et al., 2011; Silva et al., 2021; Hesarinejad et al. 2021). Recent research has evaluated the texture of *Petit Suisse* cheeses (Ribeiro et al., 2021; Sánchez-Obando et al., 2020). Ribeiro et al. (2021) studied the texture of *Petit Suisse* with the addition of oat bran and found that it improves water retention capacity and texture. Sanchez-Obando (2020) evaluated the application of Microparticulated whey proteins (MWP) as a fat mimetic in *Petit Suisse*. According to the authors, the addition of 10% MWP improved the three-dimensional structure (matrix) of the reduced-fat cheese because it slightly increased the elastic and viscous modulus. On the contrary, samples with 20% fat reduction became susceptible to association with other whey proteins, decreasing their stability.

In this context, this research aimed to prepare a *Petit Suisse* cheese added of *açaí* in order to analyze the influence of the addition of thickeners on the texture and physical-chemical parameters in 3 different formulations.

2. Material and Methods

2.1 Raw material for product preparation

The ingredients used in the elaboration of the formulations were acquired in the commerce of the city of Limoeiro do Norte, CE, Brazil: Commercial *açaí* - Oca do açaí (*açaí* pulp, sugar, corn glucose syrup and artificial guarana flavor), crystal sugar - Amaresco, lactose-free cream (17% fat) - Italac, lactose-free dairy compound - Nestlé, commercial xanthan gum and flavorless gelatin - Royal. The pasteurized and standardized whole milk (3% fat) was acquired from Betânia Lácteos industry. The lactase enzyme (Maxilact LGI 5000) of microbial origin, as specified by Brazilian legislation, Resolution RDC Nº 53/ 2014 (Brasil, 2014) and the mesophilic dairy culture (DELVO®TEC LL 50ª 0.5U) containing *Lactococcus lactis* subsp. *cremoris* and *Lactococcus lactis* subsp. *lactis* were supplied by the company Globalfood.

2.2 Production of Petit Suisse cheeses

Three formulations (F_1, F_2 and F_3) of açaí *Petit Suisse* cheeses were prepared, with different proportions of thickeners, as shown in Table 1.

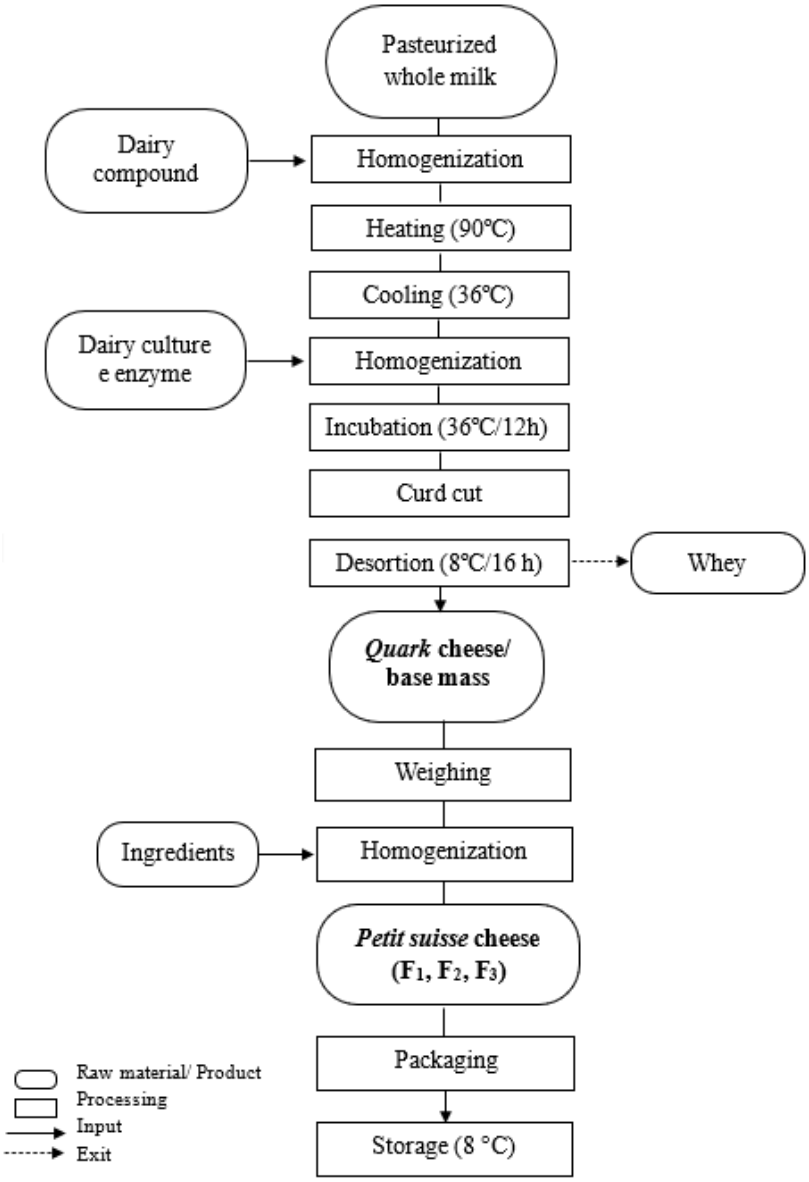
Table 1 – Formulations of *Petit Suisse* cheese added *açaí*: F_1 - Formulation with 0.1% xanthan gum; F_2 - Formulation with 0.1%; gelatin F_3 - Formulation with 0.05% xanthan gum and 0.05% gelatin.

Ingredients	**Formulations (%)**		
	F_1	F_2	F_3
Quark cheese	62.80	62.80	62.80
Frozen *acai*	10.00	10.00	10.00
Milk cream	10.60	10.60	10.60
Crystal Sugar	16.50	16.50	16.50
Xanthan gum	0.10	-	0.05
Gelatin	-	0.10	0.05

Source: Research data.

The elaboration of the cheeses was carried out based on the methodology described by Esmerino et al. (2013). Pasteurized and standardized whole milk, lactose-free dairy compound, mesophilic dairy culture and lactase enzyme were used for the production of quark cheese. The dairy compost (4%) was dissolved in the milk, heating up to 90 ºC, followed by cooling to 36 ºC, for the addition of the dairy culture and the enzyme. Then, they were homogenized and incubated at 36 ºC (± 1) in a dairy incubation chamber, for a period of 12 hours, until reaching pH 4.8, which determines the degree of fermentation of this product. The curd obtained was carefully cut and transferred to previously sterilized cotton fabric bags for draining the whey at a refrigeration temperature (8 ºC ± 1) for 16 hours. After obtaining the quark cheese, the curd was weighed, and from the amount obtained, the other ingredients were weighed (Table 1), adding them in a mixer and thoroughly homogenizing them. After this process, they were placed in plastic pots and refrigerated (± 8 °C) until the moment of analysis. Figure 1 shows the flowchart with the cheese processing steps (*Quark* and *Petit Suisse*).

Figure 1- Flowchart of the processing steps of *Petit Suisse* cheeses with *açaí* in three formulations (F_1, F_2 and F_3).



Source: Research data.

2.3 Microbiological and physicochemical analysis

Microbiological parameters were determined in the *açaí* sample using the methods recommended by the American Public Health Association (APHA, 2001). Analyzes of *Salmonella* sp., *Escherichia coli* and molds and yeasts were performed, as required by Normative Instruction of Ministry of Health Nº 60/ 2019 (Brasil, 2019).

The proximate composition, the moisture content (g $100g^{-1}$) of the *açaí* was analyzed gravimetrically (at 105 °C), and in the cheeses it was determined from the loss of mass in a Mars infrared moisture analyzer ® ID200. Proteins (g $100g^{-1}$) were determined by the *Kjeldahl* method, and the conversion factor 6.25 was used for *açaí*, and 6.38 (specific for dairy) for cheese. The fat content (g $100g^{-1}$) of *açaí* was determined following the *Bligh and Dyer* method, and of the cheeses it was obtained by the butyrometric method. Cheese sugars were determined using the Lane and Eynon (Fehling) method. Ash content (g $100g^{-1}$) of *açaí* was determined by calcination in a muffle at 550 °C (Quimis, Q-318m24) until constant weight (AOAC, 2000).

The pH was determined by potentiometry, using a pHmeter (HANNA Instruments®, model HI2221) calibrated with standard solutions pH 4.0, 7.0 and 10.0. The determination of soluble solids was performed with a bench digital refractometer (Abbe Refractometer Optronics®). *Açaí* and *Petit Suisse* samples were diluted in distilled water at a ratio of 1: 2 and 1:10, respectively, and the reading was taken. The titratable acidity was determined by potentiometric volumetry, based on the potentiometric titration of the sample with sodium hydroxide solution (0.1 N), where the equivalence point is determined by measuring the pH of the solution. The results were expressed as % lactic acid and % citric acid for cheese and *açaí*, respectively (AOAC, 2000).

2.4 Texture profile analysis

The texture profile was determined through the double penetration test TPA (Texture Profile Analysis) on 50 g of sample placed in aluminum capsules to perform the test. A 36 mm diameter probe (P/36) was used in a TA-XT2i texture analyzer (Stable Micro Systems). The parameters analyzed were: firmness, adhesiveness, elasticity, cohesiveness, stickiness and chewiness. The equipment settings for the tests were 2 cm in height, 6.2 cm in diameter and 10 mm in distance and the pre-test, test and post-test speeds were 1, 1 and 2 mm/s, respectively, following the methodology described by Barcelos et al. (2020), with modifications. Data were analyzed in five replicates collected using the Exponent Lite Express program.

2.5 Statistical analysis

The results were submitted to analysis of variance (ANOVA) and compared to each other by Tukey's test at a 5% significance level, using of the Statistica® version 7 program, and expressed as mean followed by standard deviation (Statsoft, 2004).

3. Results and Discussion

3.1 Characterization of açaí

The results obtained for the microbiological and physicochemical analyzis of *açaí* are shown in Table 2. The microbiological quality of *açaí* was evaluated according to Brazilian standards established by Ministry of Health - Normative Instruction No. 60/ 2019 (Brasil, 2019). The results indicated the absence of *Salmonella sp.* in 25 g of sample, as required by NI No. 60/ 2019 (Brasil, 2019). Values below the limits established of the legislation was detected for *Escherichia coli* (< 3 $MPN.g^{-1}$) and molds and yeasts (1 x 10^2 $CFU.g^{-1}$). Therefore, the *açaí* analyzed in this study meets the microbiological standards required by current legislation, and can be used in preparations without risks.

The classification of *açaí* is given according to the amount of water used in the edible part extraction process, as well as the subsequent elaboration steps (Brasil, 2018). The minimum content of total solids is 8 g $100g^{-1}$, therefore the *açaí* analyzed in this research is within the standard required by legislation, with 24.95 g $100g^{-1}$ of total solids. Research carried out by Aquino et al. (2019) showed values ranging from 18.13 to 24.30 g $100g^{-1}$ in eleven samples of *açaí.*

Table 2– Results (mean ± SD) of the microbiological and physicochemical parameters analyzed in *açaí.*

Parameters	**Mean ± SD (w.b)**	**Mean ± SD (d.b)**	**Legislation**
Microbiological			*
Escherichia coli (MPN.g^{-1})	< 3	-	< 10
Salmonella sp.	Ausence	-	Ausence
Mold and yeast (CFU.g^{-1})	10^2	-	$<10^3$
Physicochemical			**
Total solids (g.100 g^{-1})	24.95 ± 0.30	-	Min. 8.0
Water content (g.100 g^{-1})	75.05 ± 0.35	-	-
Total protein (g.100 g^{-1})	1.23 ± 0.00	4.93 ± 0.00	Min. 7.0
Lipids (g.100 g^{-1})	2.47 ± 0.34	9.90 ± 1.36	-
Ash (g.100 g^{-1})	0.30 ± 0.01	1.19 ± 0.02	-
pH	5.25 ± 0.05	-	4.0 – 6.2
Soluble solids (ºBrix)	21.03 ± 0.35	-	-
Titratable acidity (g.100g^{-1} acid citric)	0.16 ± 0.01	-	Max. 3.2

*MS NI Nº 60/ 2019. **MAPA Ordinance Nº 37/2018. MPN-Most Probable Numbers. CFU - Colony Forming Units. Source: Research data.

The water content found in the açai in this research was 75.05 ± 0.35 g 100g^{-1} (Table 2), a value close to the results obtained by Aquino et al. (2019) and Costa, et al., (2018). The protein content verified in the açai sample was 4.93 g 100g^{-1} d.b, which was below the standard established by legislation (7 g 100g^{-1} d.b.) for açai. Costa, et al., (2018) verified a protein content of 9.47 g 100g $^{-1}$ d.b. when the açai sample. Current legislation does not set limits for lipids in açai. The analyzed sample had a lipid content of 9.90 ± 1.36 d.s., lower than the values found in studies carried out by Oliveira and Santos (2011) and Costa, et al., (2018) (46.74 and 47.59 g 100g^{-1}, respectively). Freitas et al. (2015) also found high lipids content in three different brands of açai pulp (38, 58 and 46 g 100g^{-1}, respectively). The Brazilian legislation- Ordinance Nº 37/2018 also does not mention limits for ash in açai pulp (Brasil, 2018). The inappropriate addition of ingredients in commercial açai can cause changes in its quality. Another justification is the influence of extrinsic factors in the cultivation of fruits, whose composition is affected by several factors, such as temperature, relative humidity, type and chemical composition of the soil and because it is a product of plant origin and due to the variety of the plant, fruit harvesting, industrial processing and storage conditions.

According to Brasil (2018), the acceptable range of pH is 4.0 to 6.2 in açai. Thus, the pH of açai analyzed in this study (5.25 ± 0.05) was in accordance with what is established in the legislation for this parameter, corroborating the study by Freitas et al. (2015) and Campos et al. (2017).

Legislation does not establish reference values for soluble solids. This research detected 21.03 °Brix (Table 2), a result higher than the research by Campos et al. (2017) which detected 4.50 °Brix in frozen açai pulp. Aquino et al. (2019) cited a variation of 16.63 to 29.73 °Brix, and indicated that because they are ready-to-eat edible açai-based ice creams, they contain several additional ingredients, such as commercial sucrose, syrup, among others, and for this has higher levels than reported in other surveys. The açai in this study also showed a high value of soluble solids when compared to other studies,

which can also be explained by the ingredients that were present in this product, which, according to the label, contained sugar, corn glucose syrup and artificial guarana aroma.

The result of titratable acidity (Table 2) found in this research was 0.16 g citric acid. 100 g^{-1}, indicating that it is according the value established by Brazilian legislation (maximum of 3.2 g citric acid 100 g^{-1}) (Brasil, 2018). Açai is a fruit with low acid content, with no significant variation in acidity during storage, which can lead to greater stability in relation to this characteristic (Oliveira & Santos, 2011). Research carried out by Freitas et al. (2015) reported that all brands studied had different acidity, being them 0.09, 0.13 and 0.15 g citric acid 100 g^{-1}, corroborating present research.

3.2 Analysis of açai Petit Suisse cheese formulations

The instrumental texture analysis was carried out in order to verify the behavior of the cheeses and determine the most relevant parameters for this product. The results are shown in Table 3.

Table 3 – Instrumental Texture Profile (TPA) analysis parameters (mean ± SD)* of elaborate *Petit Suisse* cheeses.

Parameters	**Formulations**		
	F_1	F_2	F_3
Firmness (N)	$1.09^a \pm 0.03$	$0.97^a \pm 0.11$	$1.08^a \pm 0.08$
Adhesiveness	$-421.10^a \pm 13.07$	$-464.90^b \pm 20.93$	$-445.53^{ab} \pm 24.21$
Elasticity (mm)	$0.923^b \pm 0.01$	$0.941^a \pm 0.00$	$0.920^b \pm 0.01$
Cohesiveness	$0.591^b \pm 0.01$	$0.635^a \pm 0.02$	$0.595^b \pm 0.01$
Stickiness (N)	$0.65^a \pm 0.02$	$0.61^a \pm 0.07$	$0.64^a \pm 0.03$
Chewability (N.mm)	$0.60^a \pm 0.02$	$0.58^a \pm 0.06$	$0.59^a \pm 0.03$

*Means followed by the same letter on the line do not differ significantly by the Tukey test ($p \geq 0.05$). F_1 - Formulation with 0.1% xanthan gum; F_2 - Formulation with 0.1%; gelatin F_3 - Formulation with 0.05% xanthan gum and 0.05% gelatin. Source: Research data.

The evaluated formulations were similar: F_1 and F_3 showed no significant difference ($p \geq 0.05$) for textures parameters, and F_2 differed from F_3 only in elasticity and cohesiveness (Table 3). There was no statistical difference ($p \geq 0.05$) in cheese firmness. These results were close to those reported by Matias et al. (2014) in *Petit Suisse* cheese with guar gum, carrageenan and xanthan thickeners, which varied from 1.58 to 1.87 N, but differed from the results found by Souza et al. (2011) in five commercial brands of *Petit Suisse*, which ranged from 5.42 to 6.65 N.

For adhesion, it was identified that formulations F_2 and F_3 did not differ. Adhesiveness is the energy needed to overcome the attractive forces between the food surface and other materials that are in contact with it. Thus, the lowest force was verified by F_1.

The elasticity of F_1 and F_3 did not differ statistically ($p \geq 0.05$) from each other, but they did differ from the sample F_2, where this one presented a higher value, indicating that it more easily recovered its initial shape after the compression process. Similar results were observed by Souza et al. (2011), where they detected a variation from 0.95 to 0.97 for the elasticity of commercial *Petit Suisse* cheeses.

The strength of the internal bonds of the constituents of a given sample will be better when higher values are reached for the cohesiveness. Among the elaborated cheeses, it was found that F_2 had the highest average for this parameter. Considering that xanthan gum was present in F_1 and F_3, this thickener may have been the promoter of the lowest values for this parameter, therefore, with less cohesion, corroborating the study by Maruyama et al. (2006).

Gummyness is a parameter derived from firmness in TPA therefore, it is common for these parameters to present similar behavior, as observed in this study. *Petit Suisse* formulations containing xanthan gum in their composition had higher gummyness values (Maruyama et al., 2006). Matias et al. (2014) obtained similar gummyness, ranging from 0.54 to 0.71 N during the storage period of *Petit Suisse*. Chewability is also a parameter derived from firmness and in this study it was noticed that both had the same behavior. Therefore, the formulations did not show a significant difference ($p \geq 0.05$) for this parameter, indicating that the three formulations need the same strength to complete chewing.

This direct relationship between firmness and chewiness was also verified in the research by Li et al. (2020), in which they analyzed the texture parameters of creamy soy cheese during ripening. Souza et al. (2011) obtained higher results for chewing than in the present study (3.10 to 4.83 N) in the commercial *Petit Suisse* analyzed, being necessary, therefore, longer chewing time in these commercial cheeses than the cheeses in this research.

The use of different thickeners gives the product a distinct texture and different effects on its macro and microstructure, therefore, in each study, tests are carried out to verify which is the best hydrocolloid to be used (Deolindo et al., 2019). According to Matias et al. (2014), young people prefer the smoother and less grainy texture of petit suisse cheese. Comparing formulation F_2 (gelatin 0.1%) with formulation F_3 (gelatin 0.05% and xanthan gum 0.05%), it was observed that despite the instrumental texture parameters being similar, visually F_2 has a grainier texture and F_3 is smoother, it is necessary to carry out a sensorial evaluation with consumers to verify if this parameter will interfere in the purchase of the elaborated products. In this context, it was considered that the use of xanthan gum and gelatin in the elaboration of Petit Suisse cheese (F3) provided better texture.

Moisture, protein and pH analyzes were performed on the samples, as they are essential in the characterization of this product and the other physicochemical parameters were determined only in the best formulation (F_3). Table 4 shows the results of the analyzes performed on *Petit Suisse* cheeses and the characterization of the formulation F_3

Table 4 – Result (mean ± SD)* of analyzes performed on *Petit Suisse* and characterization of the best formulation (F_3).

Parameters	**Formulations****		
	F_1	F_2	F_3
Water content (g.100g^{-1})	63.07^a ± 0.15	62.00^b ± 0.26	62.17^b ± 0.38
Total protein (g.100g^{-1})	6.00^a ± 0.32	6.54^a ± 0.05	6.51^a ± 0.65
pH	4.72^a ± 0.01	4.69^a ± 0.08	4.63^a ± 0.12
Lipids (g.100g^{-1})	-	-	6.17 ± 0.58
Total sugars (g.100g^{-1})	-	-	21.30 ± 0.67
Reducing sugars (g.100g^{-1})	-	-	6.87 ± 0.08
Non-reducing sugars (g.100g^{-1})	-	-	15.54 ± 0.62
Acidity (g.100g^{-1} lactic acid)	-	-	0.56 ± 0.00
Soluble solids (ºBrix)	-	-	27.30 ± 0.00

* Means followed by the same letter on the line do not differ significantly by the Tukey test ($p \geq 0.05$). F_1 - Formulation with 0.1% xanthan gum; F_2 - Formulation with 0.1%; gelatin F_3 - Formulation with 0.05% xanthan gum and 0.05% gelatin. Source: Research data.

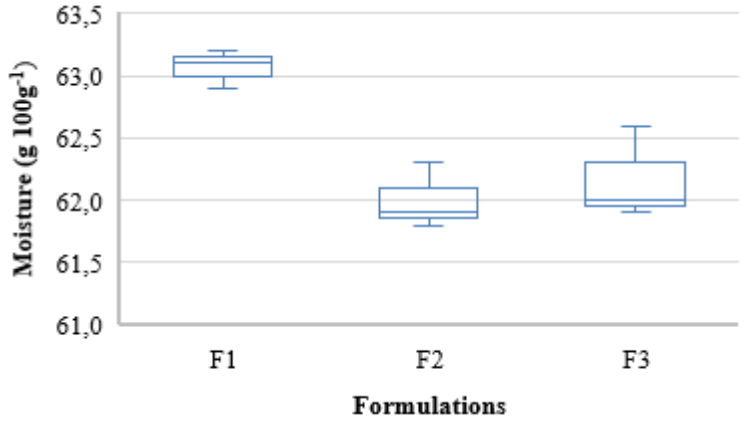
The legislation establishes that *Petit Suisse* cheeses have a moisture content greater than 55 g 100g^{-1} (Brasil., 2000). The results for moisture in this research ranged between 62.00- 63.07 g 100g^{-1}, as shown in table 4. Matias et al. (2014) found

63.90, 67.25 and 66.69 g $100g^{-1}$ of moisture for *Petit Suisse* cheese based on milk, mixed product with cream and soy cream and product based on soy milk, respectively. Barcelos et al. (2020) observed higher moisture content in potentially probiotic goat *Petit Suisse* with acerola pulp, both for the control formulation and for the one containing the pulp (73.83 to 75.27 g 100 g^{-1}, respectively). Deolindo et al. (2019) found lower values (34 to 35 g $100g^{-1}$) during 28 days of storage of *Petit Suisse* cheese made with organic Bordeaux grape juice, rind and seed extract, falling outside the classification of very high moisture cheeses.

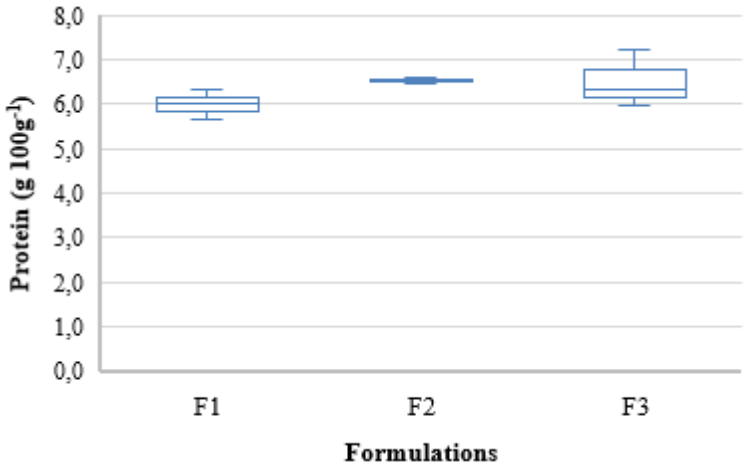
For the protein results, the legislation points to this cheese the minimum value of 6 g $100g^{-1}$, therefore, the three formulations are within the standard established in the current legislation, showing no significant difference ($p \geq 0.05$). Barcelos et al. (2020) obtained protein content of 6.73 g $100g^{-1}$ and 6.31 g $100g^{-1}$ for the control and acerola pulp formulations, respectively. In a study conducted by Cardarelli et al. (2008) a higher protein content (ranging from 8.89 to 9.93 g $100g^{-1}$) was observed in eight *Petit Suisse* formulations produced with oligofructose, inulin and oligosaccharides.

The pH values of the formulations showed no significant difference ($p \geq 0.05$), and remained close to the pH of the cut-off point. However, it is normal for a reduction in pH to occur, since it is a natural process caused by the continuous production of lactic acid and other acids by the bacteria added for fermentation (Cardarelli et al., 2008). The control of pH in fermented dairy products is essential to maintain their characteristics, since a sudden reduction can cause draining, in addition to making the product more acidic, causing rejection by consumers. In the research by Deolindo et al. (2019) lower pH values were observed, ranging from 3.58 to 4.02, in the period from 0 to 28 days of storage. Barcelos et al. (2020) obtained pH close to the present study (3.86 to 4.07). Figure 2 shows the box plot comparing the cheese formulations F_1, F_2 and F_3 in relation to moisture, protein and pH parameters.

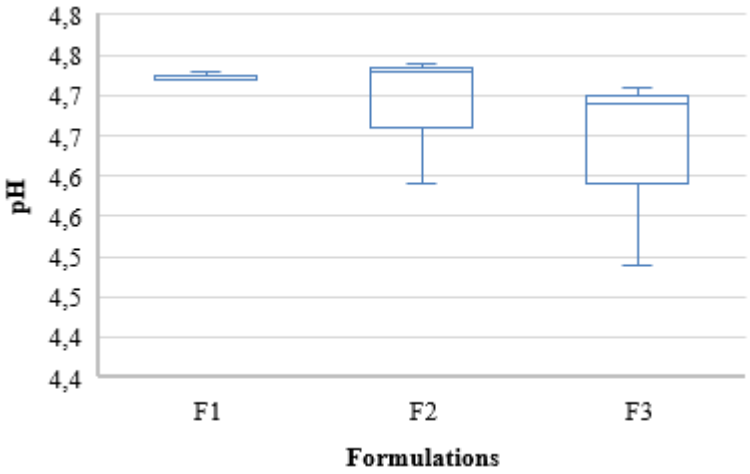
Figure 2 – Box plot obtained from (a) moisture, (b) protein and (c) pH analyzes performed on *Petit Suisse* cheeses added açai (F_1, F_2 and F_3).



(a)



(b)



(c)

Source: Research data.

Thus, the best formulation considered in this study (F_3) was characterized through the analysis of lipids, sugars, acidity and soluble solids. The result of the detected fat content (Table 4) is close to that found by Barcelos et al. (2020) in the control formulation of *Petit Suisse* cheese made with goat's milk. The results are similar in that the fat content of the two types of milk (goat and cow) used in these studies are similar. The total sugar content of this formulation was similar to the results verified by Renhe et al. (2018) in *Petit Suisse* with low lactose content (21.8 g $100g^{-1}$) and in *Petit Suisse* with 20% sugar reduction (21.6 g $100g^{-1}$). However, when comparing with the reducing and non-reducing sugars of the same research, it appears that the results obtained were divergent, where the authors obtained 11.2 g $100g^{-1}$ for the reducing sugars, and 10.5 g $100g^{-1}$ for non-reducing sugars. The results for acidity differed from all the results found by Deolindo et al. (2019) during 28 days of storage of *Petit Suisse* made with lyophilized grape seed extract, where it ranged from 1.84 to 0.83 g $100g^{-1}$ of ac. lactic. However, the data were similar to the results of Barcelos et al. (2020) who verified a variation from 0.60 to 0.62 g $100g^{-1}$ of lactic acid in cheese with the addition of acerola pulp. The soluble solids content identified in PS3 differed from the results found by Deolindo et al., 2019 over 28 days of storage of *Petit Suisse* made with Bordeaux grape juice, where they detected a variation of 12 to 19 °Brix. However, 16.5% of sugar was used in the manufacture of the cheese in the present research, whereas in the research by Deolindo et al. (2019) was a smaller amount (13%), justifying the difference in values.

4. Conclusion

The use of a thickener in *Petit Suisse* influenced its quality and modified the texture, in which the application of an isolated hydrocolloid, either xanthan gum or gelatin, conferred non-conforming characteristics on the product. The formulations were similar in the analyzed parameters, but it was identified that Petit Suisse with a mixture of xanthan gum and gelatin (F3) presented the best formulation. The production of *Petit Suisse* cheese with the addition of açai is an innovative product for the food market, and can be indicated for audiences of different age groups, providing a cheese option with high nutritional value. For better results of application to the market, it is suggested the accomplishment of sensorial analysis, in addition to the evaluation of the life of shelf

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