

Development of *petit suisse* Cheese with Native Fruits: Blackberry (*Morus nigra* L cv. Tupy) and Guabiroba (*Campomanesia xanthocarpa* O. Berg)

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Abstract: The use of native fruits is relevant for the development of innovative and healthy products. This work evaluated the production of *petit suisse* cheese with addition of blackberry (*Morus nigra* L cv. Tupy) (15 and 25%) and guabiroba (*Campomanesia xanthocarpa* O. Berg) pulps (10 and 20%), varying the concentration of guar (0.15, 0.30 and 0.45), xanthan (0.10, 0.20 and 0.30%) and carrageenan (0.00 and 0.05) gums. The *petit suisse* cheeses with fruit pulps were subjected to sensory evaluation, showing no significant difference ($p > 0.05$) in the odor, flavor, taste and global acceptability between the formulations and high level of acceptability ($> 76\%$). Two formulations, with 25% blackberry pulp (guar, xanthan and carrageenan gums) and 20% guabiroba pulp (guar and xanthan gums), were chosen considering their physicochemical characterization, sensory and principal components analysis. Both samples showed distinct physicochemical characteristics ($p < 0.05$) differing from each other. The color of the pulps influenced the color of the final product, as well as the other physicochemical parameters. The developed products presented a higher energy content when compared with commercial similar products and presented microbiological stability for 33 days (*petit suisse* with blackberry pulp) and 28 days (*petit suisse* with guabiroba pulp), when stored at 10°C.

Keywords: Development, Sensory Evaluation, Gums, Fruits Pulp, Cheese, Native Fruits, Nutritional Profile

1. Introduction

Cheese is a product widely consumed in Brazil, produced through the coagulation of milk with lactic acid bacteria that ferment lactose and produce lactic acid, decreasing the pH. *Petit suisse* cheese, is a fresh, unripened cheese, which can be added with fruit pulps, with creamy appearance, high moisture and must be preserved and commercialized at temperatures under 10°C [1-3]. Brazil is the third largest producer of fruit in the world producing orange, banana, watermelon, pineapple, grape and others, totalizing 39.9 million tons in 2017. Its production is destined for domestic

and foreign markets [4, 5]. The interest of Brazilian native fruits has been growing, due to the presence of antioxidant substances such phenolic compounds, vitamins and minerals that contribute to the prevention of many diseases. Darker colored fruits commonly have high levels of flavonoids, elevated antioxidant activity and are being called super fruits by food industry. Thus, these fruits can be used as a functional ingredient in the preparation of food products, in order to attend global trend for healthy and natural food products consumption [6-11]. Blackberry fruits (*Morus nigra* L cv. Tupy) are actually formed by a grouping of smaller fruits, with consistent and firm texture, uniform dark color, balanced flavor between acidity and sugar with intense flavor

and widely consumed *in natura* [12]. It is an important source of bioactive phenolic compounds as anthocyanins, responsible for their coloring characteristic [13, 14]. Studies with native Brazilian fruits, such as “goiaba-serrana”, “açai”, “pitanga”, “mangaba”, “guabiroba” and blackberry, have been carried out by researchers in order to show their potential and encourage the consumption of these native species as food, adding value to these natural resources. Blackberry planting in Brazil has increased, mainly in the South region, where the climate and soil are favorable [15-17]. Guabiroba (*Campomanesia xanthocarpa* O. Berg), popularly known as “guabirova”, “guariba” or “gavirova”, is a native fruit from the southern region of Brazil. The fruits have a rounded shape with a greenish-yellow color, citrus aroma, sweet flavor, vitamins and carotenoids. Guabiroba pulp is used in food industry as flavoring ingredient in liquors, juices, ice creams [18-21]. Regarding to development of *petit suisse* cheese, the literature reported the use of acerola pulp [22], jabuticaba extract [23], juice, peel and seed extract of Bordeaux grape [24], *petit suisse* cheese with low lactose content and reduced sugar addition [25], reduced fat content with whey retention [26], addition of inulin and oligofructose [27], and the addition of gooseberry, moringa leaf powder and gelatin [28].

Considering the valorization and importance of the native fruits as food ingredients, in development of new products, the objective this work was to evaluate formulations of *petit suisse* cheese with blackberry and guabiroba pulps and their sensory and physical-chemical characteristics.

2. Material and Methods

2.1. Pulp Production

Blackberry and guabiroba were obtained in the Cantuquiriguassu region - Paraná - Brazil (latitude 25°24'03"S, longitude 52°24'26 "W, altitude 825 m) and harvested at point of maturation. Fruits were washed, sanitized with chlorine (100 mg L⁻¹ for 10 min), pulped (pilot pulper with 0.8 mm sieve), pasteurized (85°C for 30 min), wrapped (low density polyethylene bags – PEBD) frozen and stored (-18 ± 2°C) until use.

2.2. Physical Chemical Characterization of Fruit Pulps

The determination of moisture, total solids, lipids, protein, ash, total carbohydrates, pH, water activity, titratable acidity (% citric acid) [31] and color (Konica MinoltaOptics, Inc - Chroma Meter CR- 400/410, L * a * b * / CIELAB system), were performed in triplicate.

2.3. Quark Cheese Preparation

Quark cheese was produced using whole pasteurized cow milk (3.0% fat), heated to 37°C with addition of 0.25 gL⁻¹ CaCl₂ (Alphatec®). The mixture was homogenized and the starter culture - *S. thermophilus* (Chr. Hansen®) was introduced following the manufacturer's guidelines. When the pH was between 6.3 and 6.5, 0.8 mL⁻¹ of coagulant

liquid (Chr. Hansen®) was added to the mixture with subsequent homogenization. After enzymatic coagulation (pH 5.5 - 5.8), the curd was cut, left to rest for 30 min, after which was transferred to a cotton filter system (morim), sieved and stored at 9 ± 1°C for 12 to 18 h for desorption. The quark cheese was packaged and kept at 9 ± 1°C for 2 h. This procedure was repeated at least five times.

2.4. Petit Suisse Cheese Preparation

Quark cheese was homogenized with UHT (Ultra high temperature) 17% fat sour cream (Italac®), refined sucrose (Alto Alegre®) and fruit pulp (blackberry or guabiroba). Guar, xanthan (Oxquim®) and carrageenan (CPKelco®) gums were previously dissolved in water at 25°C with 10 g of sucrose. The mixture was homogenized and the *petit suisse* cheese was packaged in 145 mL polypropylene jars, covered with aluminum seals and stored at 9 ± 1°C until use.

The concentrations of sucrose and sour cream (14% and 13% respectively) remained constant in the *petit suisse* cheese formulations, varying pulp fruits and gums concentration (Table 1). The content of fruit pulp and gums were defined by experimental design in previous tests. In the formulation with guabiroba pulp, the variation of carrageenan gum at concentrations from 0.05% to 0.15% did not influence the texture of the product, thus this gum was removed from formulation. The percentage of quark cheese was adjusted to complete the formulation by 100%.

Table 1. *Petit suisse* cheese formulations with blackberry and guabiroba pulps.

Ingredients (%) *	Formulations					
	B1	B2	B3	G1	G2	G3
Quark Cheese	57.50	47.25	47.70	62.50	52.75	52.25
Fruit pulp	15.00	25.00	25.00	10.00	20.00	20.00
Guar gum	0.30	0.45	0.15	0.30	0.15	0.45
Xanthan gum	0.20	0.30	0.10	0.20	0.10	0.30
Carrageenan gum	0.00	0.00	0.05	-	-	-

*Sucrose (14%) and sour cream (13%) are fixed. Bn – *Petit suisse* formulation with blackberry pulp; Gn - *Petit suisse* formulation with guabiroba pulp; n - formulation number.

2.5. Sensory Analysis

Before *petit suisse* formulations were subjected to sensory profile, microbiological analysis was performed: *Staphylococcus aureus*, *Salmonella* spp. and thermotolerant coliforms. Sensory analysis (approved by the Committee of Ethics in Research, CAAE: 46412415.0.0000.5564 - Federal University of Fronteira Sul) was carried out in the sensory laboratory at 23°C, in ambient with white light, free from noise and odors, with 59 non-evaluators trained, male and female, over 18 years old. Participants received three samples containing 20 g of blackberry and guabiroba *petit suisse* cheese, served in disposable plastic cups. Samples were evaluated for color, appearance, odor, texture, flavor, taste and global acceptance using a hedonic scale of nine points (1 referring to “dislike extremely” and 9 “like extremely”) and

the purchase intention using a hedonic scale of five points (1 referring to “Certainly would not buy” and 7 “Certainly would buy”). The Acceptability Index (AI) was calculated using equation (1), where “A” is the average score obtained for the formulation and “B” is the maximum score of the scale [29].

$$AI (\%) = (A/B) * 100 \quad (1)$$

2.6. Physicochemical *Petit Suisse* Cheese Characterization

The select samples (B3 - *petit suisse* of blackberry and G2 - *petit suisse* of guabiroba), were subjected to analysis of titratable acidity, expressed in % of lactic acid [30], color (Konica Minolta Optics handheld colorimeter, Inc - Chroma Meter CR-400/410) with values expressed in the L * a * b * / CIELAB system, ashes, total solids, pH and moisture [31], fat content [32], protein [33], water activity using an electronic analyzer (LabMaster - Novasina®) at 25°C with temperature control system and carbohydrate by difference [31]. The analysis was done in triplicate.

2.7. *Petit Suisse* Cheese Shelf-Life

Shelf-life analysis of formulations B3 and G2, were based on the determination of molds and yeasts [34] and visual syneresis for 33 days. Weekly, three samples of each formulation were taken for analysis, made in real triplicate.

2.8. Statistical Analysis

Results were submitted to Analysis of Variance (ANOVA) and the means compared by Tukey's test with 95% confidence level using ActionStat® software. Statistical treatment of sensory analysis data was evaluated using the Statistica® software version 8.0 [35] by Principal Component Analysis in multivariate analysis (PCA) and Hierarchical Cluster Analysis (HCA, single linkage method).

3. Results and Discussion

3.1. Physical-Chemical Characterization of Fruit Pulps

Blackberry and guabiroba pulps (Table 2) presented high moisture content (wet basis) (> 81.41%) and elevated water activity content (0.99), which indicates that proper storage will be required to prevent microbiological growth [36]. After harvest, cleaning and selection, pulp processing must be done immediately to avoid loss of nutrients and guarantee the quality of the product [21]. Guabiroba pulp presented pH 4.13 and blackberry pulp showed lowest pH value (3.26) and highest acidity (1.01% in citric acid). These acid characteristics were detected in a previous sensory evaluation study [37].

Table 2. Proximate analysis (wet basis) (g100g⁻¹) of blackberry and

guabiroba pulp.

Composition (%)	*Blackberry pulp	*Guabiroba pulp
Moisture	92.42 ± 0.23	81.41 ± 0.30
Ashes	0.05 ± 0.03	0.37 ± 0.02
Total soluble solids	7.57 ± 0.23	18.59 ± 0.30
Lipids	1.75 ± 0.33	4.34 ± 0.59
Protein	1.31 ± 0.04	1.87 ± 0.04
Total carbohydrates	4.45 ± 0.49	11.99 ± 0.30
**water activity	0.99 ± 0.00	0.99 ± 0.00
**pH	3.26 ± 0.01	4.13 ± 0.01
Titratable acidity (% citric acid)	1.01 ± 0.10	0.79 ± 0.06

* Mean ± standard deviation; **dimensionless values.

Guabiroba pulp exhibited higher values of carbohydrate (11.99%) and lipid (4.34%) when compared to blackberry pulp (4.45% and 1.75%, respectively). Carbohydrates (mono, oligo and polysaccharides) are the second main constituent of fruits and influence on sensory characteristics, especially in sweet fruits [38]. Lipids influence the palatability, flavor and texture of food [39]. According to [40, 41], physicochemical characteristics of guabiroba pulp can influence the sensory attributes of the final product, due to its characteristics of fibrous texture, grassy and viscous, and being sweeter when compared to blackberry pulp. Furthermore, guabiroba is a functional fruit with an acid-sweet flavor, high content of dietary fiber, phenolic compounds, vitamin C [42, 43], and greater amount of fibers that increases the sensation of thickness, viscosity and sticky residue [44].

Physical-chemical characterization results for blackberry and guabiroba pulps where similar to values reported in the literature [45-50]. On the other hand, studies carried out with blackberry pulps [51] and guabiroba [50] showed differences in lipids content (blackberry pulp) and acidity (guabiroba pulp). The pulping process can result in the presence of small parts of husks and seeds in the pulps, which can influence the physical-chemical characterization, since these materials present a higher content of lipids and proteins [12]. The values of the physical-chemical analysis of the pulps presented in different studies can be justified due to the characteristics of the fruit itself, which may vary depending on the cultivar, climatic conditions and ripeness [52, 53].

Regarding to color measurement (Table 3), the luminosity of the blackberry pulp (L=22.34) was lower than the luminosity observed in the guabiroba pulp (L=49.97), which is consistent with its naturally darker coloring. In the CIE color diagram, the coordinates + a * and + b * indicated a dark purple color for the blackberry pulp and reddish yellow for the guabiroba pulp, as can be visually correlated in the laboratory obtained pulps (Figure 1).

Table 3. Color, chroma and hue angle of blackberry and guabiroba pulps.

Pulps	L*	a*	b*	C*	Hue angle
Blackberry	22.34 ± 0.08	13.66 ± 0.21	5.71 ± 0.04	14.81 ± 0.22	22.68 ± 0.20
Guabiroba	49.97 ± 0.21	11.72 ± 0.88	42.55 ± 1.24	44.13 ± 0.21	74.61 ± 0.69

* Mean ± standard deviation.

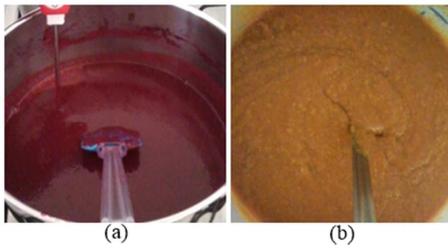


Figure 1. Visual image of blackberry (a) and guabiroba (b) pulps.

3.2. Sensory Analysis

Sensory analysis of *petit suisse* cheese (Table 4) with blackberry pulp showed that attributes appearance, odor,

texture, flavor and global acceptance did not differ ($p > 0.05$). Sample B3 (25% pulp) presented a higher statistical score in color attribute (7.96 ± 1.16) when compared to sample B1 (15% pulp) (7.32 ± 1.16). This indicates that the increase in the concentration of the pulp contributes favorably on the color of *petit suisse* cheese and this characteristic pleases the consumer. In all sensory attributes, *petit suisse* cheese formulations with blackberry pulp showed scores between 7 and 8, corresponding to “like moderately” and “like very much”. Regarding the purchase intention, the formulations presented values higher than 5 referring to “maybe buy” on the hedonic scale.

Table 4. Sensory evaluation and purchase intention of *petit suisse* cheese with blackberry and guabiroba pulps.

Attributes	Formulations					
	B1	B2	B3	G1	G2	G3
Color	7.32 ± 1.16^b	7.82 ± 1.14^{ab}	7.96 ± 1.16^a	7.29 ± 1.36^a	7.31 ± 1.37^a	7.62 ± 1.16^a
Appearance	7.43 ± 1.22^a	7.84 ± 0.97^a	7.79 ± 1.13^a	7.17 ± 1.20^b	7.22 ± 1.28^b	7.75 ± 1.12^a
Odor	7.22 ± 1.32^a	7.00 ± 1.48^a	7.44 ± 1.19^a	7.12 ± 1.25^a	6.89 ± 1.38^a	7.36 ± 1.34^a
Texture	7.77 ± 1.43^a	7.34 ± 1.42^a	7.43 ± 1.24^a	6.86 ± 1.29^b	7.37 ± 1.53^{ab}	7.82 ± 1.17^a
Flavor	7.34 ± 1.36^a	7.29 ± 1.36^a	7.43 ± 1.35^a	6.89 ± 1.20^a	7.20 ± 1.30^a	7.17 ± 1.31^a
Taste	7.58 ± 1.43^a	7.05 ± 1.50^a	7.65 ± 1.66^a	6.74 ± 1.66^a	7.00 ± 1.67^a	7.39 ± 1.41^a
Global acceptance	7.43 ± 1.17^a	7.15 ± 1.30^a	7.06 ± 1.45^a	6.89 ± 1.34^a	6.89 ± 1.32^a	7.36 ± 1.13^a
Purchase intention	5.65 ± 1.30^a	5.22 ± 1.32^a	5.79 ± 1.35^a	4.70 ± 1.57^a	4.98 ± 1.54^a	5.43 ± 1.28^a

Means followed by the same letter on the same line do not differ by Tukey's Test ($p > 0.05$); Bn and Gn – *petit suisse* cheese formulation with blackberry and guabiroba pulp.

Sensory analysis of *petit suisse* cheese with guabiroba pulp showed no significant difference ($p > 0.05$) in the attributes color, odor, flavor, taste and global acceptance (Table 4). Regarding the texture, it was not possible to establish a sensory correlation with the amount of gums added in the formulation. The sample with the highest gum content (G3 - 0.75%) had a statistical score (7.82 ± 1.17) similar to the sample with the lowest gum content (G2 - 0.25%) (7.37 ± 1.53), indicating that the sensory texture of the product depends on the type of gum added. Guar, xanthan and carrageenan gums are commonly used in formulations of dairy products, which contribute to texture, viscosity and avoid the syneresis of products [54-55]. The sensory texture parameter can be influenced by the amount of guabiroba pulp added, with the highest scores referring to samples G3 and G2 with 20% pulp. The formulations with guabiroba pulp, obtained scores higher than 6 and 7 (“like slightly” and “like moderately”), which indicates a future perspective of adjustments in the formulations of this product in order to make it even more attractive to the consumer.

Purchase intention attribute showed no significant difference ($p > 0.05$) between samples formulated with the same type of pulp (blackberry or guabiroba). These results differed from a study of *petit suisse* cheese with jaboticaba extract [56], when the authors notice that color and viscosity can influence the purchase intention, since they are associated with the high global acceptance of the product.

The acceptability index (Table 5) of *petit suisse* cheese formulations was higher than 76% (exception from taste of

sample G1). Considering this index, if these products were launched to the market, they would have expectancy of being accepted by the consumer [29-57].

Table 5. Acceptability index of *petit suisse* cheese.

Attributes	Acceptability index (AI)					
	B1	B2	B3	G1	G2	G3
Color	81.33	86.89	88.44	81.00	81.22	84.67
Appearance	82.56	87.11	86.56	79.67	80.22	86.11
Odor	80.22	77.78	82.67	79.11	76.56	81.78
Texture	86.33	81.56	82.56	76.22	81.89	86.89
Flavor	81.56	81.00	82.56	76.56	80.00	79.67
Taste	84.22	78.33	85.00	74.89	77.78	82.11
Global acceptance	82.56	79.44	78.44	76.56	76.56	81.78

Bn and Gn – *Petit suisse* cheeses formulations with blackberry and guabiroba pulp.

According to studies of *petit suisse* cheeses with grape-peel flour and grape seed extract [24], the authors did not observe any difference ($p = 0.745$) in the sensory acceptance index between the control (71%) and formulations with grape seed extract (73%). These results suggested that the grape seed extract, rich in phenolic compounds, did not interfere in the acceptability and sensory properties of *petit suisse* cheese.

Whereas product formulations influence sensory evaluation, different *petit suisse* cheese formulations of blackberry and guabiroba were studied using a multivariate exploratory analysis (PCA). Results shown in Figure 2 indicate that all variables are directly negatively correlated by CP1 (total variance of 64.40%), while in CP2 (total variance

of 17.95%), the variables odor, flavor, taste and texture are negatively correlated with the variables appearance and color.

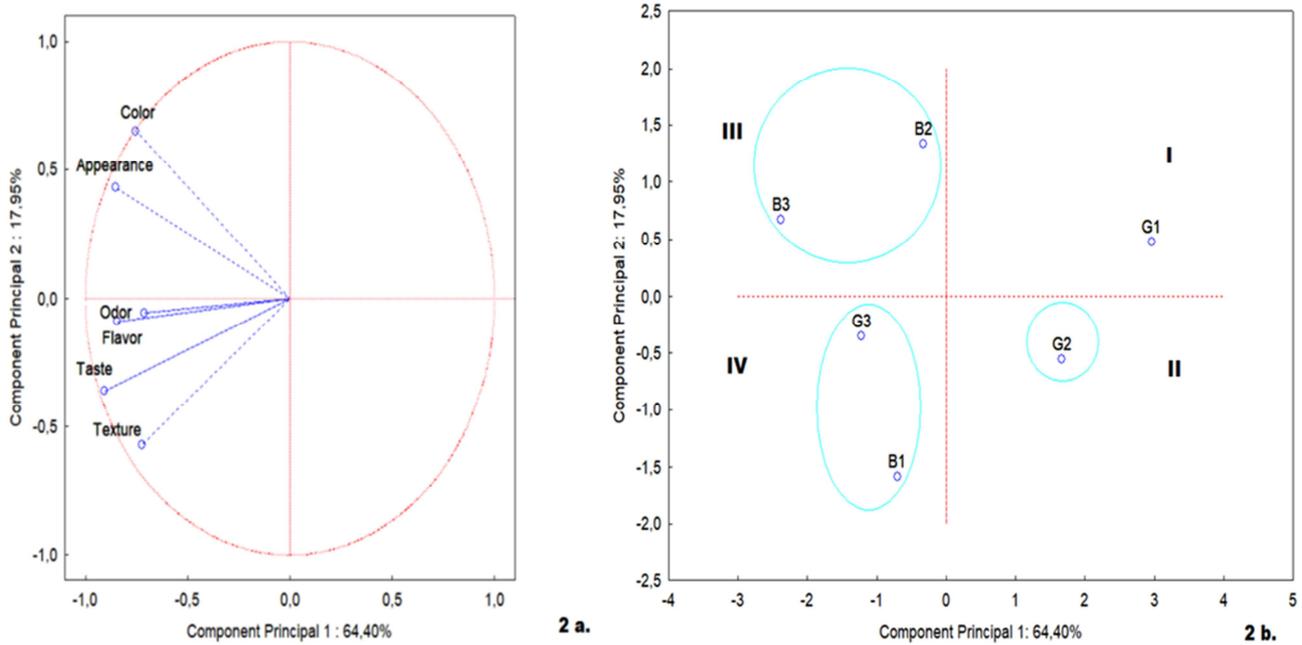


Figure 2. Plotted data in coordinate system given by the two most important components with different clusters marked by highlighted colors: (a) variable weights and (b) variation correlation of the score.

All sensory attributes showed a negative and significant correlation by CP1 (color $r=-0.75$; appearance $r=-0.85$; odor $r=-0.71$; texture $r=-0.72$; flavor $r=-0.84$ and taste $r=-0.90$ respectively, with $p \leq 0.05$). These components are responsible for grouping the three groups, shown in Figure 3.

formulation presented sensory characteristics quite different from formulations B1 and G3, but with characteristics intermediate to those of formulations B2 and B3. In the negative quadrant of x and positive of y (Group III) are observed the formulations B2 and B3, which have a greater correlation between the attributes color and appearance.

The HCA (Figure 3) shows 3 main groupings of the sensory attributes and confirms the correlations performed by the PCA. One of the HCA clusters grouped the formulations with sensory characteristics distinct from the others according to the first two PCA clusters and the other two joined the last two PCA clusters, where the formulations presented a greater correlation between the sensory attributes, also showing that there is a smaller difference between the formulations of group IV of the PCA (group with greater homogeneity).

Considering the formulations used and the results obtained, it was decided to choose two formulations of *petit suisse* cheese, one from each fruit pulp to continue the study. All sensory attributes of the *petit suisse* cheese formulations showed an acceptability index (AI) higher than 70% and the acceptance scores and purchase intention between the *petit suisse* cheese formulations for both pulps, did not show any significant difference ($p > 0.05$). Thus, it was defined by selecting samples B3 (25% blackberry pulp with 0.15% gums) and G2 (20% guabiroba pulp with 0.25% gums). These formulations contained the highest content of fruit pulp, lowest content of gum and distinct sensory characteristics (confirmed by PCA analysis - Figures 2 and 3), which could attend consumers with different profiles. Thus, it was chosen formulations with the highest amount of pulp, in order to obtain a differentiated product from traditional ones with less gum content, with a view

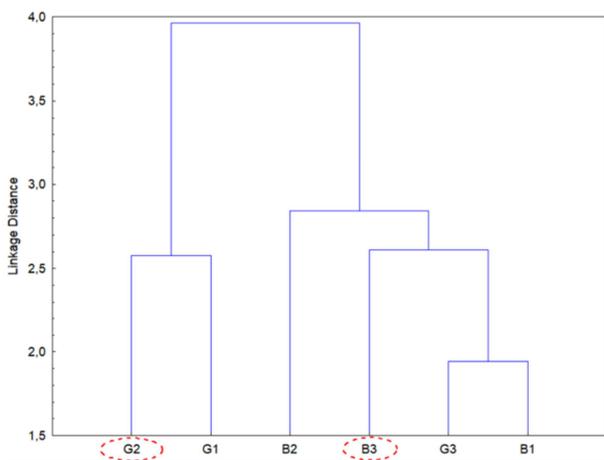


Figure 3. Dendrogram obtained after Cluster analysis (Euclidean distance, single linkage) using the sensorial properties evaluated for the *petit suisse* cheese elaborated with blackberry and guabiroba pulps.

Considering the analysis in Figure 2, it is possible to observe that formulations G3 and B1, situated in the negative quadrant of x and y (Group IV), were characterized by a similar odor, flavor, taste and texture. In the positive x and negative y quadrant (Group II), only G2 formulation stands out, presenting intermediate sensory characteristics of odor and flavor for B2 and B3 formulations. In the positive quadrant of x and y (Group I) is observed that G1

to maintaining product quality at a lower cost.

3.3. Physicochemical Characterization of *Petit Suisse* Cheese of A3 and G2 Formulations

Petit suisse cheeses with blackberry and guabiroba (Table 6) showed high values of water activity (> 0.93), which is a favorable condition for the development of pathogenic and

deteriorating microorganisms, if the product is not properly produced, packaged and stored. The Technical Regulation for Identity and Quality of *petit suisse* Cheese (Normative Instruction (IN) N° 53, December 29, 2000, [1]) establishes conditions for the storage of *petit suisse* cheese at temperatures not exceeding 10 °C, as a way to guarantee its microbiological safety, a condition used in the present study.

Table 6. Composition (wet basis) (g 100 g⁻¹) of blackberry and guabiroba *petit suisse* cheese.

Composition (%)	Blackberry <i>petit suisse</i> *	Guabiroba <i>petit suisse</i> *	F _{calc}	p-value
Moisture	68.48 ± 0.11	64.38 ± 0.15	1,469.61	0.00
Ashes	0.41 ± 0.04	0.59 ± 0.01	71.16	0.00
Total soluble solids	31.54 ± 0.11	35.62 ± 0.15	1,469.61	0.00
Lipids	3.53 ± 0.15	4.73 ± 0.12	117.82	0.00
Protein	6.46 ± 0.04	6.16 ± 0.53	1.061	0.36
Total carbohydrates	21.09 ± 0.32	24.12 ± 0.56	66.42	0.00
**water activity	0.93 ± 0.06	0.95 ± 0.05	0.094	0.765
**pH	4.21 ± 0.01	4.54 ± 0.07	66.22	0.00
Titrateable acidity (% citric acid)	1.27 ± 0.07	1.00 ± 0.03	38.43	0.00

B3 – Blackberry *Petit suisse*, G1 – Guabiroba *Petit suisse*. * Mean ± standard deviation. p<0.05 there is no significant difference. ** dimensionless values.

Protein values of 6.46% (*petit suisse* with blackberry pulp) and 6.16% (*petit suisse* with guabiroba pulp) attended values established by federal legislation [1], minimum of 6%. The other parameters showed statistically different physical-chemical composition (p < 0.05). This behavior was similar to the PCA analysis that showed different sensory characteristics between samples B3 and G2, indicating that both could please differently types of consumers.

Carbohydrates, lipids and proteins content in *petit suisse* cheeses are strongly influenced by the ingredients used in the formulations. The guabiroba pulp had 11.99%, more than double of the carbohydrates of blackberry pulp (4.45%). The addition of 20% of pulp in the G2 formulation, resulted in a higher carbohydrate content in the formulation of *petit suisse* cheese with guabiroba. This same behavior was observed in relation to the content of lipids in the formulation. The pH of the cheeses was 4.21 and 4.54 (with blackberry pulp and guabiroba pulp, respectively), these values are typical in dairy products due to the natural production process of lactic

acid and other organic acids by result of lactose fermentation in the presence of starter cultures [54].

The physical-chemical characteristics obtained in this study are similar to studies reported in the literature, which evaluated *petit suisse* cheeses using different types of gums [54], high-fat milk cream [26], without lactose [25] and with acerola pulp [22].

Petit suisse cheese colors (Table 7), revealed that the luminosity of the blackberry *petit suisse* (L=56.28) was lower than the *petit suisse* with guabiroba pulp (L=71.63), which characterizes it as a darker product. Considering the CIE color diagram (Figure 4a), it can be noticed purple color (*petit suisse* with blackberry pulp) and yellow color (*petit suisse* with guabiroba pulp). It is also observed (Figures 4b and 4c) that the coloring characteristics of the pulps were determinant in the coloring characteristics of the final products. This effect can help the consumer to relate the color of the product with the presence of the *in natura* fruit.

Table 7. Color, chroma and hue angle of *petit suisse* chesses with blackberry and guabiroba pulps.

Formulation	L*	a*	b*	C*	Hue angle
B3 - blackberry <i>petit suisse</i>	56.18 ± 0.18	16.62 ± 0.26	0.84 ± 0.02	16.63 ± 0.26	2.90 ± 0.11
G2 - guabiroba <i>petit suisse</i>	71.63 ± 0.55	-0.94 ± 0.05	31.50 ± 0.72	31.51 ± 0.73	91.75 ± 0.13



Figure 4. Diagram representing the color of the products using (a) CIE color diagram and pictures that show the colors of *petit suisse* chesses with (b), blackberry pulp, (c) guabiroba pulp.

The nutritional table of the formulations were elaborated considering the physical-chemical and federal legislation [58], and compared with three commercial brands (Table 8). It was observed that *petit suisse* cheeses with blackberry and guabiroba presented higher energy content when compared to other commercial samples. This fact is due to the greater

presence of carbohydrates and fats in comparison to the commercial products. Concerning protein content, values observed were similar to commercial brands. These differences in nutritional composition are directly correlated with the ingredients used in the formulations.

Table 8. Nutritional table of *petit suisse* cheeses with blackberry pulp, guabiroba pulp and commercialized brands, considering 40g per portion.

<i>Petit suisse</i> Cheese Nutritional Information per 40g							
	Blackberry		Guabiroba		Brand 1	Brand 2	Brand 3
		%DV *		%DV *			
Energetic value (kcal / kJ)	87.40 - 365.7	4	92.08 - 385.3	5	39.00 - 164	46.00 - 192	60.44 - 253
Total carbohydrates (g)	11.00	4	11.46	4	4.60	6.30	6.22
Proteins (g)	2.50	3	2.70	4	2.50	2.50	2.58
Total fat (g)	3.70	7	4.00	7	1.20	1.20	1.60
Saturated fat (g)	2.10	10	2.31	11	0.80	0.70	1.07
Fibers (g)	0.10	0	0.57	2	-	-	-
Sodium (mg)	51.50	2	57.84	2	27.00	16.00	32.89
Vitamin D (mg)	1.00	-	1.06	-	1.50	-	0.66
Vitamin E (mg)	0.20	2	0.10	1	-	-	1.33
Calcium (mg)	88.60	9	107.98	11	150.00	-	115.56
Zinc (mg)	0.30	4	0.34	5	-	-	1.09

*DV: Daily values based on a 2000 kcal or 8400 kJ diet.

3.4. *Petit Suisse* Cheeses Shelf-Life

Syneresis was not visually observed during shelf-life evaluation of the *petit suisse* cheeses, which is an important indicator of product physical stability. Regarding to the presence of molds and yeasts (Table 9), the current legislation (RDC N ° 12, of January 2, 2001 – [59]) does not establish limits for molds, however, it has been considered previous legislation, where fungi and yeasts must not exceed 5×10^3 CFUg⁻¹, equivalent to 3.7 log CFUg⁻¹ [60] - No. 146). On the 33rd. day of storage, the *petit suisse* cheese with blackberry pulp presented 3.4 log CFUg⁻¹, lower than legislation limit. The microbiological analysis in the 24th day presented sampling problems, however, considering the trend of the results obtained, it can be assumed that the value corresponding to this day would be lower than the value of 3.4 log CFU g⁻¹ of the 33rd day.

On the 24th day of storage of guabiroba *petit suisse* cheese, mold and yeast count presented 3.1 log CFUg⁻¹. Considering that on the 33rd day the value of molds and yeasts (5.2 log CFUg⁻¹) exceeded legal limit, for guabiroba *petit suisse* cheese the shelf-life was 24 days. This behavior can be occur due to the natural occurrence of the microbiota initial count in the fruit pulp, or a greater susceptibility to microbiological development due to a higher pH value of the guabiroba *petit suisse* cheese, when compared to the product formulated with blackberry, considering that these formulations were produced without use of food preservatives. According to [61], molds and yeasts are the main responsible for the deterioration of cheeses, which highlights the importance of its control. In addition, mold contamination deserve attention, due to the fact that some species are mycotoxin producers, capable of causing damage to consumer's health [62]. Considering aspects related to shelf-life evaluation of this

kind of product, control of production parameters and temperature during transport and storage are important.

Table 9. Yeasts and molds during storage time.

Days	Blackberry <i>petit suisse</i> cheese (log CFUg⁻¹) - B3	Guabiroba <i>petit suisse</i> cheese (log CFUg⁻¹) - G2
0	<1.0	<1.0
4	1.0	1.0
11	1.0	2.3
19	1.6	2.6
24	0.0*	3.1
33	3.4	5.2

* Sampling problems.

4. Conclusions

The use of fruit pulps, such as blackberry and guabiroba were considered adequate for the production of *petit suisse* cheese. Physicochemical parameters of fruit pulp influenced directly *petit suisse* characteristics. *Petit suisse* cheeses formulations with blackberry and guabiroba pulp showed good sensory acceptability, appropriate physical and chemical characteristics and potential industrial production and commercial acceptance. Considering the microbiological stability regarding molds and yeasts, *petit suisse* cheeses could be stored at 10 °C for a period of up to 33 days (with blackberry pulp) and 24 days (with guabiroba pulp).

5. Recommendations

It is recommended for future works the investigation of shelf life of *petit suisse* cheeses with variation on storage conditions and evaluation of its texture using instrumental analysis.

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