INTERNATIONAL SEVEN JOURNAL
OF MULTIDISCIPLINARY
ISSN: 2764-9547

Development of fermented goat's milk drink

Desenvolvimento de bebida láctea fermentada de leite de cabra

DOI: 10.56238/isevmjv3n3-016
Receipt of originals: 03/12/2024
Publication acceptance: 04/02/2024

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ABSTRACT

The goat dairy industry has been growing in recent decades, with cheese being the product with the highest demand, and consequently, there is a large generation of whey. This co-product, if eliminated without prior treatment, can cause environmental problems, since it has a high biochemical demand for oxygen. The elaboration of milk beverage is a simple and attractive alternative for the use of whey. 2 formulations of fermented milk beverage (40% and 50% whey) were elaborated, with the addition of coffee and amarula flavor, and their physicochemical and sensory quality were evaluated. In the pH analysis, in 15 days of storage, there was a decrease of 0.3 units for the formulation with 40% serum (FB), corresponding to a 7.5% reduction in pH, thus showing a 3 to 9% reduction within the predicted value. On the other hand, the formulation with 50% serum (AP) obtained a reduction of 0.4 units. In the syneresis evaluation, the results showed that, after 22 days of storage, the serum separation was only 3 cm (16%), remaining stable at this point in both formulations. There was no significant difference between the samples in the sensory analysis for all the attributes evaluated. In addition, a variety of perceptions among the tasters were revealed, both negative and positive words. In this way, the development of the fermented goat milk drink coffee with amarula flavor allows the obtaining of a product with good sensory acceptance, simple execution, high nutritional value and low cost, showing itself as a promising alternative to add greater economic value to whey and goat milk.

Keywords: Whey, Milk, Utilization, Coffee.

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INTRODUCTION

Global goat milk production has more than doubled in the last 50 years and is expected to increase by approximately 53% by 2030 (PULINA et al., 2018). Approximately 2% of the world's milk production comes from goat farming, representing significant economic importance for both developed and developing countries (GESTARO et al., 2021). Brazil produces about 25.3 million liters per year of goat's milk, with almost 70% of this production being in the Northeast region and 24.70% being produced in the Southeast region, representing about 95% of the national production (IBGE, 2017). Due to its nutritional benefits, goat milk products have become a thriving niche for the dairy industry (CENACHI *et al*., 2011).

Goat milk differs from bovine and human milk due to its emulsifying capacity, therapeutic properties in medicine and human nutrition (PARK *et al*., 2007), as it has higher digestibility and lower allergenic potential when compared to cow's milk, which is associated with its composition. In relation to fat globules, they have a smaller diameter, and this aspect influences greater digestibility in the human body due to a better distribution in the lipid emulsion (CENACHI *et al*., 2011; PARK *et al*., 2007). Unlike bovine milk, β-CN is the main protein in goat's milk and the casein in goat's milk contains less αs1-casein, which is the fraction responsible for most allergies associated with cow's milk. For this reason, people allergic to bovine milk may respond well to goat milk (HAENLEIN, 2004; CHACÓN VILLALOBOS, 2005). Lactose is the main carbohydrate in goat's milk, but its content is lower than in cow's milk. Other carbohydrates present in goat's milk are oligosaccharides, which have anti-infective and prebiotic properties (AMIGO; FONTECHA, 2011). In addition, goat's milk is an excellent source of biodigestible calcium, phosphorus, and magnesium because it contains higher amounts of these minerals in soluble form (SLAČANAC et al., 2010).

The goat-based dairy industry has been growing in recent decades, with cheese being the most demanded product. The production of cheese generates whey as the main "waste", which if eliminated without previous treatment, can cause environmental problems, since it has a high biochemical demand for oxygen. The development of products in the dairy industry, aiming at an adequate use of whey as a raw material, is an alternative to reduce costs with waste treatments, in addition to being an interesting alternative from a nutritional point of view (SLAČANAC *et al*., 2010).

Several studies have been carried out to evaluate the sensory quality of fermented goat's milk, such as qualitative descriptive analysis of yogurts made with milk of different breeds and probiotic cultures, whipped yogurt made with different contents of cow's and goat's milk, among

others. The results indicated that fermented goat's milk may have distinct sensory characteristics compared to fermented cow's milk, with more intense flavors and aromas and a slightly creamier texture. Additionally, the sensory quality of fermented goat's milk can vary depending on factors such as the type of starter culture (bacterial culture used for fermentation), fermentation time, fermentation temperature, and post-fermentation treatment. These factors can influence the organoleptic characteristics of the final product (DRUNKLER *et al*., 2001; BOZANIC *et al*., 2001; UYSAL-PALA, 2003; MARTÍN-DIANA et al., 2003; UYSAL PALA *et al*., 2006).

Studies highlight the need to increase the production and market of goat products to modify the sensory perception of potential consumers and increase the consumption of goat's milk, since low sensory acceptance is common in populations not accustomed to the consumption of goat products. It has been shown that knowledge about the positive properties of goat's milk is not enough to increase its consumption, and the main reasons for non-consumption are: lack of knowledge, little availability of products and feeling nauseous when consuming it (CHACÓN VILLALOBOS *et al.*, 2008; MORGAN; GABORIT, 2001).

The preparation of dairy beverages is a simple and attractive option for the use of whey. Dairy beverages are characterized as products made with the mixture of milk and whey (the dairy base of these products represents at least 51% of the total ingredients), and may or may not have the addition of other products or food substances. The objective of this work was to develop a fermented milk drink from goat milk whey from the production of goat cheese.

MATERIAL AND METHODS

The study was carried out in the laboratories of the Celso Suckow da Fonseca Federal Center for Technological Education, Valença unit.

For the elaboration of the fermented milk drinks, the following raw materials were used: goat's milk, goat's milk whey, refined sugar (Union brand), lactic yeast (YoFlex YF-L812 brand CHR HANSEN) culture composed of: *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus salivrius subsp.thermophilus*, instant coffee (Nescafé Tipo Suave brand) and amarula essence (Arcolor brand).

The milk and whey were supplied by the Capril do Lago dairy, producers of Saanen goats, located in the municipality of Valença-RJ, in the southern region of Rio de Janeiro.

To make the coffee syrup, water (53%), sugar (40%) and coffee (6%) were added to a pot. After mixing the ingredients, the syrup was pasteurized (80 °C for 4 minutes) and cooled (25 °C) and finally, amarula essence (1%) was added.

Milk and whey were used in the development of two formulations, with concentration variations. Whey was incorporated as a way of using the residue, sugar to give it a sweet taste and lactic acid bacteria for fermentation, mainly causing the changes in viscosity and pH characteristic of the product.

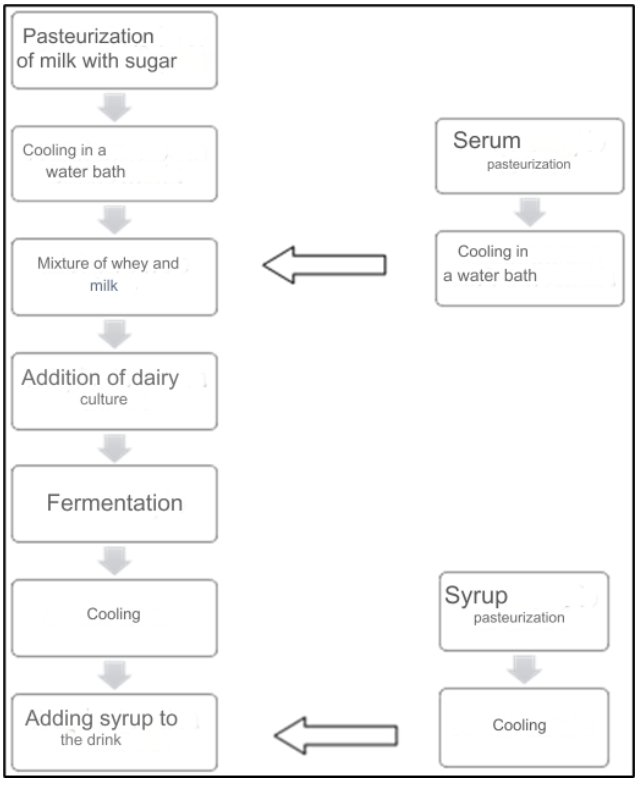
The amount of serum was based on the work of SILVA (2020). Two formulations were elaborated, as shown in Table 1, varying only the proportions of whey and goat's milk, with the milk beverage formulation fermented with 50% whey (FA), and the milk beverage formulation fermented with 40% whey (FB).

Table 1: Formulation of fermented milk beverages**.** *The volume of the dairy-based ingredients adds up to 100% and the other ingredients are calculated from this value.

Ingredients	Quantity (%)	
	FA	FB
Whole goat leite*	50	60
Whey*	50	40
Sucrose	10	10
Dairy culture	1	1
Coffee broth	7,5	7,5

The steps carried out in the production of fermented milk beverages are shown in Figure 1:

Figure 1: Flow chart of elaboration of fermented coffee milk drink with amarula



First, the milk and whey were packed separately in previously sanitized containers to proceed to the pasteurization stage. The milk was added with sucrose before heat treatment at 90ºC/5 minutes. The pasteurization of whey, with the same binomial, aimed mainly to inactivate the enzymes used in the production of cheese and to destroy pathogenic and spoilage microorganisms. Then, the raw materials were cooled to 42°C, with the objective of promoting favorable conditions for the growth of the lactic culture, proceeding to the mixing stage, respecting the proportions of the formulations proposed by the work.

After the addition of the yeast, the formulations were placed at 42 °C in B.O.D (Consul) and maintained until the pH reached around 4.6 (approximately 4 hours of fermentation), being cooled to 5°C. Subsequently, the previously pasteurized syrup was added to the fermented beverages, slowly mixed for total homogenization and packaged in transparent 330 ml bottles, finally stored at 5 ± 1 ºC, until the analysis was performed.

pH DETERMINATION

Milk and whey were analyzed at the reception of the raw material, while samples of dairy beverages were analyzed at intervals of 0, 3, 6, 10, 15 and 22 days of storage since their preparation. pH determination was performed using a digital phmeter (Bel Engineering brand) calibrated with pH buffer solutions 4.0 and 7.0.

SYNERESIS

During storage, the syneresis process of the amount of whey separated from the beverages that were in transparent bottles of 330 ml, 19 cm high, was evaluated. The analysis was performed with the aid of a ruler in which the serum supernatant was measured in relation to the total height of the container. The measurement was made over the course of the days, at intervals of 3, 6, 10, 15 and 22 days since its elaboration. This methodology was based on Lucey's (1998) method in which the supernatant liquid was measured in a beaker. The methodology was adapted to the use of a ruler instead of a beaker.

SENSORY ANALYSIS OF FERMENTED MILK BEVERAGES

The sensory tests were carried out at the Laboratory of Sensory Analysis and Product Development of CEFETR/RJ, with the participation of 100 tasters, including students and employees of the institution (of both sexes, age range from 14 to 70 years). Participants were

invited to read and sign the Free and Informed Consent Form approved by the Ethics Committee of UNIFOA (University Center of Volta Redonda), under CAAE No. 66356222.8.0000.5237.

The acceptance test was performed using a nine-point Hedonic Scale (ranging from "very disliked", number 1, to "very liked", number 9) for the attributes of color, aroma, texture, flavor and overall impression. The Purchase Intent Test was also performed, using a 5-point scale (ranging from "would certainly buy" to "would certainly not buy"). In order to collect more information about the characteristics of the formulations, the tasters were asked to write positive and negative words about the samples.

The samples were presented in a monadic manner in disposable cups coded with three randomized numbers, containing 30 mL of milk beverage. Participants were instructed to evaluate each parameter separately and to drink water and cream crackers between the consumption of each sample.

STATISTICAL ANALYSIS

The statistical treatment of the results obtained was done by comparing the means of the parameters evaluated, with the generation of the ANOVA table and with the use of the t-test in the transformed means, establishing statistical significance for 5% probability ($p<0.05$). The analyses were performed using Microsoft Excel version 2021 and Sisvar version 5.6.

RESULTS AND DISCUSSION

pH DETERMINATION

The pH of milk and whey was verified at the reception of the raw material and the results obtained were 6.53 and 6.24 respectively. The pH of the milk was within the expected range since the pH range for goat's milk is between 6.50 and 6.80.

Table 2 shows the evolution of the pH values of the two fermented milk beverages, obtained over 22 days at 5 °C. The end of the fermentation process was determined when the dairy beverages reached the pH range between 4.56 - 4.68, which occurred after 4 hours of fermentation.

Table 2: Evolution of the mean pH values of fermented dairy beverage samples over 22 days of storage (n=2, mean ± standard deviation)

Formulation (% serum)	Ph					
	0 days	3 days	6 days	10 days	15 days	22 days
AF (50%)	4.57 ± 0.01A	4.53 ± 0.01Ab	4.42 ± 0.01Ac	4.20 ± 0.01Ad	4.12 ± 0.01Ae	4.00 ± 0.01Af
FB (40%)	4.68 ± 0.01Ba	4.62 ± 0.01Bb	4.53 ± 0.01Bc	4.39 ± 0.01Bd	4.36 ± 0.01Be	4.18 ± 0.01Bf

Note: Different uppercase letters reflect significant differences between columns for each day. Different lowercase letters reflect significant differences in the line over the days.

It is possible to observe that the pH decreased over the days in both formulations, which was already expected. The FA sample (50%) showed a more pronounced decreasing behavior compared to the FB sample (40%), a result similar to the pH values obtained in the work of Silva (2020), in which beverages with higher whey concentrations showed a more significant pH decrease, but in practice they do not interfere with the quality of the final product.

When comparing the pH between formulations, it was found that from time 0 the two samples presented pH values with significant differences. This may have been caused by the low concentration of soluble solids and other factors such as temperature variation in the beverage formulation process.

Based on the results obtained, there was a more pronounced reduction of pH in the first 10 days of storage, which results from a maintenance of residual metabolic capacity of the fermentative bacteria, which decreases as the pH reaches values close to 4.3 - 4.4. This stabilization behavior reinforces the idea that the reduction of pH during the storage period is capable of limiting the process of excessive post-acidification in fermented products (TAMIME; ROBINSON, 1991).

The phenomenon known as post-acidification occurs due to the metabolic activity of lactic acid bacteria during the storage of beverages, even when refrigerated, and continues for a certain period of time. This process can lead to a reduction in pH levels between 3% and 9%, resulting in an increase in the acidity of the product between 9% and 39% (SILVA, 2020).

In 15 days of storage, the decrease of 0.3 units, observed in the present study for the formulation with 40% serum (FB), corresponding to a 7.5% reduction in pH, was thus within the expected value. On the other hand, the formulation with 50% whey (FA) obtained a reduction of 0.4 units, corresponding to a 10% reduction in pH In 22 days of storage, there was a decrease in pH by 0.5 units in both formulations, corresponding to a 12.5% reduction. At the end of this time, dairy beverages still had good sensory characteristics.

SYNERESIS

Syneresis is a common phenomenon in fermented dairy products such as yogurts and dairy beverages. This is the natural separation of whey, which occurs due to several factors, including the composition of the product, fat content, acidity, and storage conditions (GOMES, 2012).

The results showed that, after three days of storage, the serum separation was only 3 cm, which corresponds to 16% (55 ml), remaining stable up to 22 days. It was also observed that the formulation with a higher concentration of serum (FA) presented syneresis in a shorter storage time than the beverage with a lower concentration of serum (FB), which took more days to separate the serum. This can be explained by the relationship between proteins and whey, as the concentration and interaction of dairy proteins have a significant impact on gel stability. In dairy beverages with a higher amount of whey, the ratio of protein to whey may be unfavorable for gel formation and retention, resulting in greater syneresis (SKRYPLONEK; DMYTRÓW; MITUNIEWICZ-MAŁEK, 2019)

The low rate of syneresis can be attributed to several factors, such as the product formulation, the manufacturing process, and the storage conditions. The composition of the beverage, including the concentration of total solids, fat content, and interaction between ingredients, can play an important role in reducing syneresis. In addition, adequate refrigeration conditions during storage can help control syneresis (TAMIME; ROBINSON, 1991).

The results obtained in the present study indicate that syneresis in the milk beverage was relatively low. The separation of the serum of only 3 cm (16%) after 22 days of storage suggests a good stability of the product in relation to syneresis. In a study carried out by GOMES (2012) it was found that the milk drink made with goat's milk and whey obtained the lowest syneresis index compared to the drinks made with bovine milk and whey, which can be explained by the microstructure and composition of goat's milk, which has higher casein micelles, when compared to bovine milk, resulting in a protein network with fewer pores and higher density, allowing for greater water retention. The author also points out that these low syneresis values found may be related to the higher calcium content present in goat's milk and the water retention capacity of this mineral, as a result of the establishment of ionic interactions between caseins within the protein network.

The stability of the beverage in relation to syneresis is a positive aspect, as the excessive presence of whey can compromise the texture and sensory quality of the product. A lower separation of the whey can also indicate good cohesion and structure of the product, which

contributes to a pleasant sensory experience when consuming the beverage. Figure 2 shows the displacement of the serum in the bottle between the first and last day.

Figure 2A: Displacement of serum after 3 and 22 days of storage.

SENSORY ANALYSIS OF FERMENTED MILK BEVERAGES

The FA and FB formulations did not show significant differences ($p > 0.05$) in relation to all parameters evaluated in the sensory acceptance test (Table 3).

Table 3: Mean acceptance test scores (n=2, mean ± standard deviation)

Formulation (% serum)	Colour	Aroma	Texture	Flavor	Global Assessment
AF (50%)	7.55± 1.95th	7.27 ± 2.52th	7.20 ± 2.81	6.39 ± 4.18th	6.88 ± 2.79th
FB (40%)	7.49 ± 1.85th	7.60 ± 2.59th	7.08 ± 2.70th	6.98 ± 3.32	7.26 ± 2.13th

Note: Identical letters in the same column indicate that there was no significant difference in the results by the T test ($p<0.05$).

These results partially corroborate the data obtained by Gomes (2012), who elaborated three formulations of fermented milk beverages with mixtures of whey and goat and cow's milk, in different concentrations, with the addition of guava jelly, and between the formulations studied, there were no significant differences between the attributes, as in this study.

The averages of the attributes (Color, Aroma, Texture) of the two formulations were above 7 (I liked it regularly). Such grades are considered good in an acceptance assessment.

These results were similar to the results obtained in the study by Wanderley (2021), in which he developed milk drinks based on goat milk for athletes, and obtained flavor as the only attribute that showed a difference between the beverages made and also the one that obtained the lowest score. Also in the study by Wanderley (2021), the averages obtained for the taste and texture of the goat drink were lower than the other drinks, which can be justified by the fact that

goat milk whey drinks have less acceptance in relation to the flavor attribute. The author also concluded in her study that other factors that may be associated with a lower acceptance of goat whey-based beverages are mainly a less thick consistency, which makes them more liquid and have a less noticeable tactile sensation. This fact, along with the lower density of goat whey and a more intense flavor compared to other milk varieties due to the higher amount of short-chain fatty acids, may explain the lower averages found in the study. In addition, consumers are more accustomed to consuming cow's milk, since the production of this type of milk is significantly higher in Brazil.

In view of the results obtained, as there was no significant difference between the evaluated attributes of the two formulations, it can be considered an interesting result, because as the objective is to make the most of whey in the beverage, without altering its sensory characteristics, the two formulations could be used for the elaboration of the milk beverage.

The evaluation for color did not obtain a higher score, because according to the comment of some tasters who judged the need for the drink to have a coffee color, a darker brown. Regarding texture, the precipitates suspended in the beverage may have been the factor that negatively contributed to the score. The taste may have been evaluated with lower marks due to the goat aftertaste naturally present in goat products and the tasters were not accustomed to the consumption of goat products.

More than half of tasters would "probably buy" or "certainly buy" the dairy beverages. The results were satisfactory as more than 50% of the tasters would certainly buy or probably buy both formulations and less than 20% only, probably would not buy or certainly would not buy the drinks.

During the sensory analysis, positive and negative words were collected about the samples, presented in Figures 3 and 4.

Figure 3: Positive words related to the sensory characteristics of dairy beverages.

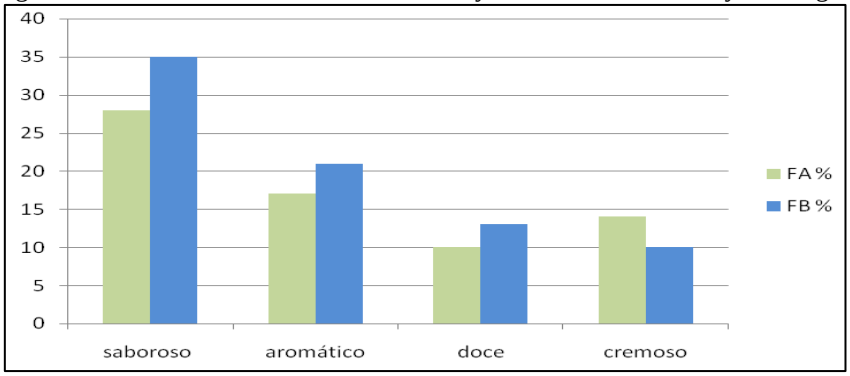
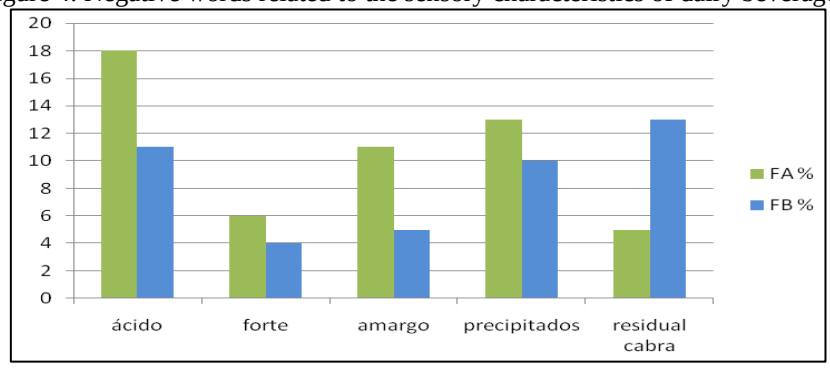


Figure 4: Negative words related to the sensory characteristics of dairy beverages.



Several positive terms were mentioned that highlighted attractive points of the drink, such as "fragrant", "smooth", "tasty", "creamy", "innovative", "coffee candy", "coffee", "yogurt", "Yakult", "refreshing", "protein", "cappuccino" and "childhood", demonstrating the perception of positive attributes for the tasters. These sensory characteristics can be indicative of a pleasant experience when consuming the beverage, such as an attractive aroma, creamy texture, and flavors that refer to pleasant childhood moments, such as the taste of coffee with milk.

Among the negative terms mentioned by the tasters, "acidic", "bitter", "goat aftertaste" and "precipitated/lumpy" stood out. These elements may indicate potential taste, texture, and quality issues perceived by tasters. The term acid can refer to the natural acidity characteristic of the fermented milk beverage. The aftertaste of goat can be a distinguishing and challenging factor for the taste buds of some consumers, since not everyone is used to this characteristic taste. Regarding the precipitates, they can come from protein denaturation after pasteurization or from protein denaturation due to fermentation that reduces the pH that causes precipitation of proteins.

The FA beverage had a lower frequency of the term tasty when compared to FB. The opposite was observed for the term acidic, strong, bitter and precipitate. Another interesting result is that the FA sample was pointed out as the least tasty, however, it obtained a lower frequency for the residual term goat and a higher frequency for the terms strong, acid and bitter than FB, indicating that the most striking characteristics for consumers were acidity and bitterness.

Still in relation to sensory analysis, the results of the survey revealed that most of the tasters (51%) belonged to the age group of young adults, aged between 20 and 40 years. These participants showed a higher degree of satisfaction with the beverage and attributed the highest scores to the sensory attributes evaluated. This indicates a positive preference and a greater appreciation of the sensory characteristics of the beverage by participants in this age group. On

the other hand, the age group of adolescents, comprising individuals aged 14 to 20 years, represented 31% of the tasters, and it was the participants who gave the lowest scores. Finally, adult tasters, aged between 40 and 70 years, accounted for approximately 18% of the total participants. This age group also had positive evaluations and gave higher marks compared to the younger audience. This suggests that adults, with a greater experience and diversity of flavors throughout their lives, may have a greater acceptance of the beverage in question or due to the fact that they are more adept at using coffee on a daily basis, unlike the adolescent public.

These results highlight the influence of age group on sensory perception and evaluation of food and beverages, and therefore, it is interesting to consider these differences when developing products and marketing strategies in order to meet the preferences and expectations of individuals of different ages.

CONCLUSION

The samples of fermented dairy beverages with 50% and 40% whey incorporation did not show significant differences between the attributes evaluated.

Considering the intention to add as much whey as possible and preserve the acceptability of the product by the consumer, it can be considered that the two formulations can be used to continue the development of a new product in the dairy.

The development of the coffee-flavored fermented goat milk drink allows the obtaining of a product with good sensory acceptance and purchase intention during 22 days of storage. At the same time, it makes it possible to obtain a product of simple execution, high nutritional value and low cost, proving to be a promising alternative in order to add economic value to goat whey and goat milk. This milk drink makes it possible to increase the income of rural producers, small dairies and diversify the offer of a new flavor option of fermented milk drink in the market.

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