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ORIGINAL ARTICLE

Semi-hard buffalo cheese: how cow's milk affects sensory acceptance?

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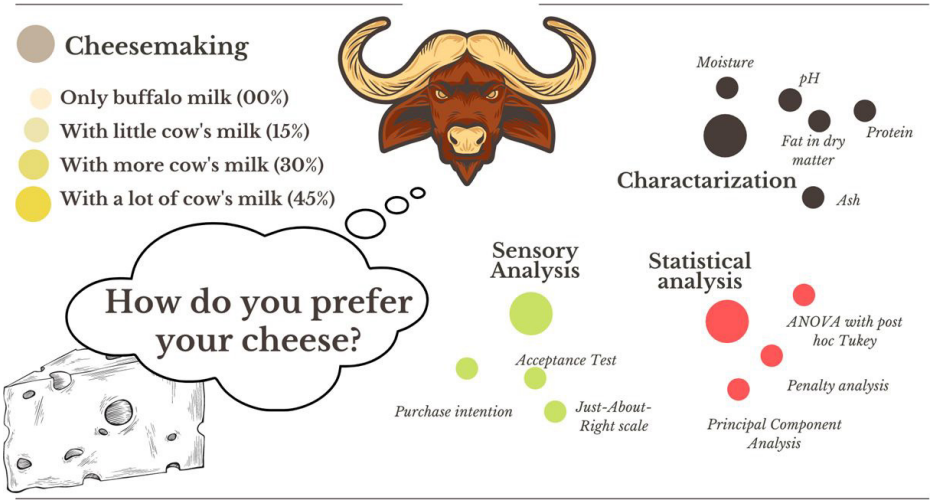
Abstract

This study aimed to highlight the effect of cow milk addition (0, 15, 30, and 45%) on Brazilian semi-hard buffalo cheese. Four formulations with different buffalo and cow milk ratios (v/v) were prepared: CC00 (100:00%); CC15 (85:15%); CC30 (70:30%); and CC45 (55:45%). The CC00 presented the highest moisture, fat in dry matter, and salt contents, while CC45 exhibited the highest protein and lowest pH values. CC45 presented the highest flavor, texture, overall acceptability, and purchase intention. Therefore, cow milk addition at 45% is an alternative to improve Brazilian semi-hard buffalo cheese's acceptability and purchase intention and, consequently, a market opportunity for the diversification of buffalo dairy products.

Keywords: Buffalo milk; Coalho cheese; Consumer expectation; Dairy product; Food formulation; Ripening; Sensory analysis.

Graphical Abstract



Highlights

- 45% of cow milk could promote positive sensory acceptance and purchase intention of buffalo cheese
- Cheese appearance was improved by adding cow milk in the new formulation
- Even in the minor proportion, cow milk reduced the buffalo cheese production yields

1 Introduction

Cheeses are products of complex biochemical events and give unique flavor and texture characteristics in different types of cheese (Moreira et al., 2019). Buffalo cheeses are often associated with mozzarella cheese, but they can be used as raw material for semi-hard and hard cheeses (Darnay et al., 2022) and the ripening of semi-hard buffalo cheese is able to improve sensory attributes such as texture, color and aroma (Kisworo, 2022). Among cheeses in Brazil, coalho cheese, a Brazilian semi-hard cheese with ten days of ripening, is the most traditionally produced and consumed, representing the Northeast's important socioeconomic and nutritional role. This cheese production generates income for large and small dairy establishments in rural areas (Soares et al., 2019).

Buffalo milk has higher levels of total casein, minerals, and fat when compared to cow milk (Roy et al., 2020), and these factors can positively influence cheese production. Furthermore, it can be recognized by the presence of antioxidant and anti-inflammatory components (D'Onofrio et al., 2019) and also by the abundant presence of amino acids and fatty acids of high nutritional value (Becskei et al., 2020). However, in tropical countries, buffalo milk production is seasonal and this fact limits buffalo milk in large-scale production (Carvalho et al., 2016) motivating the fraudulent use of cow milk for profit business (Cardoso et al., 2019).

Although the addition of cow milk is seen as a negative point, the mixture of both dairy matrices can not only guarantee the supply of products but also improve sensory quality and diversify buffalo dairy products in a more accessible way to the population.

This type of mixture is related to a satisfactory sensory acceptance and positive overall acceptability to the consumer market buffalo cheese (Chakraborty et al., 2021; Rekowsky et al., 2020) and is allowed by Brazilian legislation as long as information is clear to consumers about the proportions and types of milk used (Brasil, 2020). In this context, providing information on cheese characterization and sensory acceptance is a first step towards enabling the insertion of this product in the market. However, no study has evaluated these benefits in cheeses with more complex technological manufacture involving semi-cooked curd and ripening processes. In this context, this preliminary study aimed to assess the effect of cow milk addition (0, 15, 30, and 45%) on physicochemical and sensory characteristics of Brazilian semi-hard buffalo cheese.

2 Material and methods

2.1 Experimental design

The raw material (buffalo and cow milk) was obtained at the Experimental Farm of Entre Rios of Federal University of Bahia (*Universidade Federal da Bahia* (UFBA)) and kept under refrigeration (4 ºC) until the cheese was made. Four Brazilian semi-hard buffalo cheese treatments were developed with the inclusion of cow milk: CC00 (100% buffalo milk); CC15 (85% buffalo milk and 15% cow milk); CC30 (70% buffalo milk and 30% cow milk), and CC45 (55% buffalo milk and 45% cow milk). Buffalo milk was always in a more significant proportion in the mixture, and cheeses of each treatment were made in three replicates at different times.

2.2 Cheese manufacture

The milk already mixed, in their respective proportions, was pasteurized (65 °C/30 min) and cooled to 38 °C, followed by the addition of the ingredients: start culture (Chr Hansen R-704 at 0.03% m/V); calcium chloride (0.02%

V/V); liquid coagulant (CHY-MAX® at 0.0075% V/V); and sodium chloride (Sal Lebre at 0.7% m/V) according to Vieira and Lourenço Júnior (2006). The first three ingredients were added in that order under constant agitation. After the liquid coagulant addition, this step (resting) was taken until the curd cut point (about 50 min) was obtained. The curd was fragmented in cubes of 1.5 centimeters, using a spatula followed by resting for 5 min. The stirring was carried out in two stages, alternating stirring, and resting; the first stirrings were slow for 3 minutes, followed by a 3-minute rest. The second and third agitations occurred similarly but more vigorously. Approximately 60% of the whey was removed, and the remaining pasta was heated at 70 ºC to cook the curd. Posteriorly, the whey excess was removed, and the curd was salted with sodium chloride (0.7%). The cooked and salted pasta was placed in 500 g cylindrical plastic forms and was pressed for approximately 2 hours. Maturation occurred under refrigeration (13 ± 1 °C) and controlled humidity (85 ± 1%) with thermo-hygrometer for ten days.

2.3 Chemical analyses of Brazilian semi-hard buffalo cheese

The four cheese formulations were analyzed in triplicate for the content of moisture by infrared moisture scale (I-Thermo 163 L Bel®), fat in dry matter, ash, and total nitrogen using 6.38 as a conversion factor for protein (Association of Official Analytical Chemists, 2012), salt content (Pearson, 1985), and pH by pHmeter (Kasvi®). The cheese yield was calculated according to Nehme et al (2019).

2.4 Sensory analyses and consumer acceptance

One hundred and fifty non-training consumers voluntarily participated in sensory analysis following the Ethics Committee in Research with Human Beings of *Universidade Federal Fluminense* (UFF), in Niterói (RJ), Brazil, process nº 11527113.8.0000.5243/2015 and complying with its execution and publication. All participants had no history of intolerance or allergy to milk and dairy products and regularly consumed cheeses. These were aged between 18 - 60 (26.5 ± 7.37) years, 115 (76.7%) women and 35 (23.3%) men. All participants were recruited from the UFBA, and the analyzes were carried out in the laboratory of inspection and technology of milk and dairy products (UFBA). The participants received approximately 15 g of sample cut into cubes served in coded plastic containers (50 mL) and evaluated the appearance, color, aroma, flavor, texture, and overall acceptability on a 9-point category scale (1 = immensely dislike it to 9 = remarkably like it). Additionally, salty taste, buffalo flavor, white color, and texture (hardness, consistency, and chewiness) were evaluated using a 5-point Just-About-Right (JAR) scale anchored at both extremes (1 = not enough to 5 = too much), with a central point at 3. Participants also scored their purchase intention on a 5-point scale ranging from 1 = certainly 'would not buy it to 5 = certainly would buy it.

2.5 Statistical analyses

Physicochemical parameters and sensory scores (acceptance, purchase intention, and JAR) were evaluated by Analysis of Variance (ANOVA) and the means were compared with post hoc Tukey's tests at the 95% confidence level ($p < 0.05$). Penalty analysis was carried out on JAR data to identify the penalized attributes (> 0.5 penalty score and > 20% occurrence) in each cheese formulation that could explain a decrease in the overall acceptability. Principal Component Analysis (PCA) was performed to characterize the cheeses by correlating parameters and formulations. All statistical data were performed using XLSTAT version 2012.6.08 software (Addinsoft, Paris, France).

3 Results and discussion

3.1 Physicochemical composition and cheese yield

The moisture and fat in dry matter (FDM) were ($p < 0.05$) higher for CC00 when compared to mixed cheeses (Table 1), which presented themselves as semi-fat cheeses and medium moisture.

Table 1. Physicochemical properties (mean ± standard deviation) of Brazilian semi-hard buffalo cheeses mixed with different milk ratios.

Parameters[‡]	Formulations[†]			
	CC00	CC15	CC30	CC45
Moisture (%)	49.07 ± 0.40[a]	44.86 ± 0.15[b]	44.16 ± 0.21[c]	43.03 ± 0.19[d]
FDM[§] (%)	49.09 ± 1.57[a]	36.37 ± 0.95[c]	35.95 ± 2.97[c]	43.88 ± 1.61[b]
Protein (%)	21.96 ± 0.15[d]	24.11 ± 0.43[c]	25.76 ± 0.39[b]	27.99 ± 0.51[a]
Ash (%)	4.28 ± 0.03[b]	4.59 ± 0.01[a]	4.39 ± 0.15[b]	4.02 ± 0.09[c]
Salt (%)	1.34 ± 0.01[a]	1.18 ± 0.02[b]	1.10 ± 0.02[c]	1.13 ± 0.01[bc]
pH	6.1 ± 0.04[a]	6.3 ± 0.04[a]	6.26 ± 0.01[a]	5.63 ± 0.01[b]
Cheese Yield (%)	16.11 ± 0.00	13.43 ± 0.00	12.73 ± 0.00	12.59 ± 0.00

[†]CC00 = 100% buffalo milk; CC15 = 85% buffalo milk and 15% cow milk; CC30 = 70% buffalo milk and 30% cow milk; and CC45 = 55% buffalo milk and 45% cow milk. [‡]Average with a different letter on the same line differ from each other by the Tukey's test with $p < 0.05$. [§]FDM = Fat in dry matter.

These parameters are consistent with the characteristics of cheeses with medium to high moisture and fat contents, such as coalho cheese (Silva et al., 2021). Cheeses with higher levels of buffalo milk showed lower protein levels, higher ash content, and higher pH than the CC45 formulation. This difference can be related to milk composition since diverse factors such as period lactation and season are responsible for significant variation in buffalo milk (Pasquini et al., 2018). Commonly, buffalo milk is recognized for its high content of fat, protein and mineral salts when compared to cow milk, which positively affects the efficiency of cheese production (Bittante et al., 2022; Cipolat-Gotet et al., 2015; Rekowsky et al., 2020). The acidification process occurs more slowly in the buffalo milk due to its greater buffering capacity when compared to cow milk (Ahmad et al., 2008), which may explain our findings for pH. Furthermore, the total production yield was higher for cheese made with 100% buffalo milk (CC00; 16.11%) than the mixed cheeses, in which the yield varied from 13.43 to 12.59%. This may be due to the optimization of cheese production with less addition of calcium chloride to buffalo milk (Vieira & Lourenço Júnior, 2006) when compared to the amount used for cow milk (coalho cheese) (Nassu et al., 2013).

3.2 Sensory acceptance test, JAR, and Penalty analysis

The color and appearance scores in CC00, CC15, CC30, and CC45 increased with the cow milk addition (Table 2). The highest cow milk levels positively affected the sensory perception of these parameters in cheeses. Likewise, the CC45 formulation had the highest ($p < 0.05$) texture and overall acceptability scores than all other treatments.

Table 2. Sensory evaluation (mean ± standard deviation) of Brazilian semi-hard buffalo cheese mixed with different cow milk ratios.

Parameters[†]		Formulations			
		CC00	CC15	CC30	CC45
Sensory acceptance[‡]	**Color**	6.56[c] ± 2.00	6.91[bc] ± 1.60	7.27[b] ± 1.40	7.99[a] ± 1.10
	Appearance	6.83[c] ± 1.80	7.08[bc] ± 1.50	7.39[b] ± 1.40	7.95[a] ± 1.10
	Aroma	6.83[ab] ± 1.50	6.69[b] ± 1.60	6.55[b] ± 1.70	7.25[a] ± 1.60
	Texture	6.91[b] ± 1.80	5.63[d] ± 1.90	6.33[c] ± 1.90	7.45[a] ± 1.50
	Flavor	7.14[ab] ± 1.70	6.52[c] ± 1.70	6.73[bc] ± 1.80	7.57[a] ± 1.40
	Overall acceptability	6.93[b] ± 1.70	6.13[c] ± 1.70	6.63[bc] ± 1.80	7.64[a] ± 1.20
Purchase intention[§]		3.61[b] ± 1.00	3.10[c] ± 1.10	3.41[bc] ± 1.10	4.00[a] ± 1.00
JAR[¶]	**Salty taste**	3.08[a] ± 0.70	2.63[b] ± 0.60	2.77[b] ± 0.70	3.23[a] ± 0.60
	Buffalo flavor	3.05[a] ± 0.60	2.82[b] ± 0.70	3.03[a] ± 0.70	2.94[ab] ± 0.70
	White color	3.03[a] ± 0.80	2.88[a] ± 0.70	2.97[a] ± 0.70	2.97[a] ± 0.50
	Hardness	3.13[b] ± 0.60	3.47[a] ± 1.00	3.31[ab] ± 0.80	3.14[b] ± 0.60
	Consistency	3.06[a] ± 0.60	3.25[a] ± 0.90	3.28[a] ± 0.80	3.09[a] ± 0.70
	Chewiness	3.02[ab] ± 0.60	2.81[b] ± 0.90	3.05[a] ± 0.90	3.13[a] ± 0.60

CC00 = 100% buffalo milk; CC15 = 85% buffalo milk and 15% cow milk; CC30 = 70% buffalo milk and 30% cow milk; and CC45 = 55% buffalo milk and 45% cow milk. [†]Average with a different letter on the same line differs from each other by the Tukey's test with $p < 0.05$. [‡]Values scored on a hedonic scale from 1 to 9. [§]Values scored on a hedonic scale from 1 to 5. [¶]Values scored on the Just About Right (JAR) scale from 1 to 5.

Concerning aroma and flavor, CC45 was similar ($p > 0.05$) to CC00 (control cheese) and superior to other mixed cheeses (CC15 and CC30). These results demonstrated that the highest cow milk level led to a better perception of color, appearance, texture, and overall acceptability without affecting aroma and flavor. The lower FDM, salt content, and pH values, such as the increase in the protein content in CC45, are factors that may be indirectly involved in a greater sensory acceptance of CC45 formulation. The pH and salt influence the starter culture's growth and enzymes' activity during ripening (Moreira et al., 2019), while low-fat content guarantees better interaction of the protein matrix and improvement in texture parameters (Silva et al., 2021). The buffalo and cow milk mixtures proved to be promising in fresh cheeses and led to cheeses with a more attractive sensory profile (Rekowsky et al., 2020). This fact may justify the purchase intention to be significantly higher ($p < 0.05$) for CC45 than all other formulations, and it shows that the benefits of mixture between cow and buffalo milk can be extrapolated to semi-hard and semi-cooked cheeses.

The salty taste of the CC45 treatment was slightly above the ideal in JAR, while the CC15 and CC30 treatments were considered less salty than the ideal (Table 3).

Table 3. Penalty analysis of the Just-About-Right (JAR) scores of Brazilian semi-hard buffalo cheese mixed with different cow milk ratios.

Formulations †	Salty taste		Buffalo flavor		White color	
	Not enough	Too much	Not enough	Too much	Not enough	Too much
CC00	- ‡	-	-	-	24.00% (1.29)	-
CC15	38.00%§ (1.17)¶	-	24.00% (1.04)	-	28.67% (1.03)	-
CC30	30.00% (0.99)	-	-	-	-	-
CC45	-	27.33% (0.44)	-	-	-	-

Formulations†	Texture					
	Hardness		Consistency		Chewiness	
	Not enough	Too much	Not enough	Too much	Not enough	Too much
CC00	-	23.33% (1.22)	-	23.33% (1.06)	-	-
CC15	-	53.33% (1.29)	-	43.33% (1.05)	-	-
CC30	-	39.33% (0.92)	-	38.67% (1.08)	-	28.67% (1.18)
CC45	-	21.33% (0.79)	-	-	-	21.33% (1.09)

†CC00 = 100% buffalo milk; CC15 = 85% buffalo milk and 15% cow milk; CC30 = 70% buffalo milk and 30% cow milk; and CC45 = 55% buffalo milk and 45% cow milk. ‡(-) indicates that less than 20% of consumers chose this JAR category. §The percentage of consumers who considered the sensory attribute from JAR scores insufficient or excessive. ¶The number in parentheses represents the change in average compared to the consumer response score overall acceptability.

Despite that, CC45 had the highest acceptance indicating that the traditional salty taste of coalho cheese is exceptionally relevant for accepting this product (Costa et al., 2018; Soares et al., 2019). CC15 was penalized less buffalo flavor, CC00, and CC15 by less white color (Table 3). Interestingly, cheeses with higher inclusion levels of cow milk (CC30 and CC45) were not penalized concerning buffalo flavor and white color. Also, according to the JAR, both were considered ideal for both attributes. Previous studies have shown that mixing cow and buffalo milk has a positive effect on the color of fresh cheeses (Rekowsky et al., 2020) and the yellowness are associated with increased proportion of cow milk (Chakraborty et al., 2021). As for texture, the most severe penalties were observed in CC15 and CC30 for hardness and consistency (Table 3). Once they had higher pH values, a lower proteolytic process was suggested for enzymatic or microbiological activity.

3.3 PCA analysis

According to the PCA analysis for physicochemical and sensory properties, only two PCs were needed to express 91.96% of the total variability from obtained data (Figure 1).

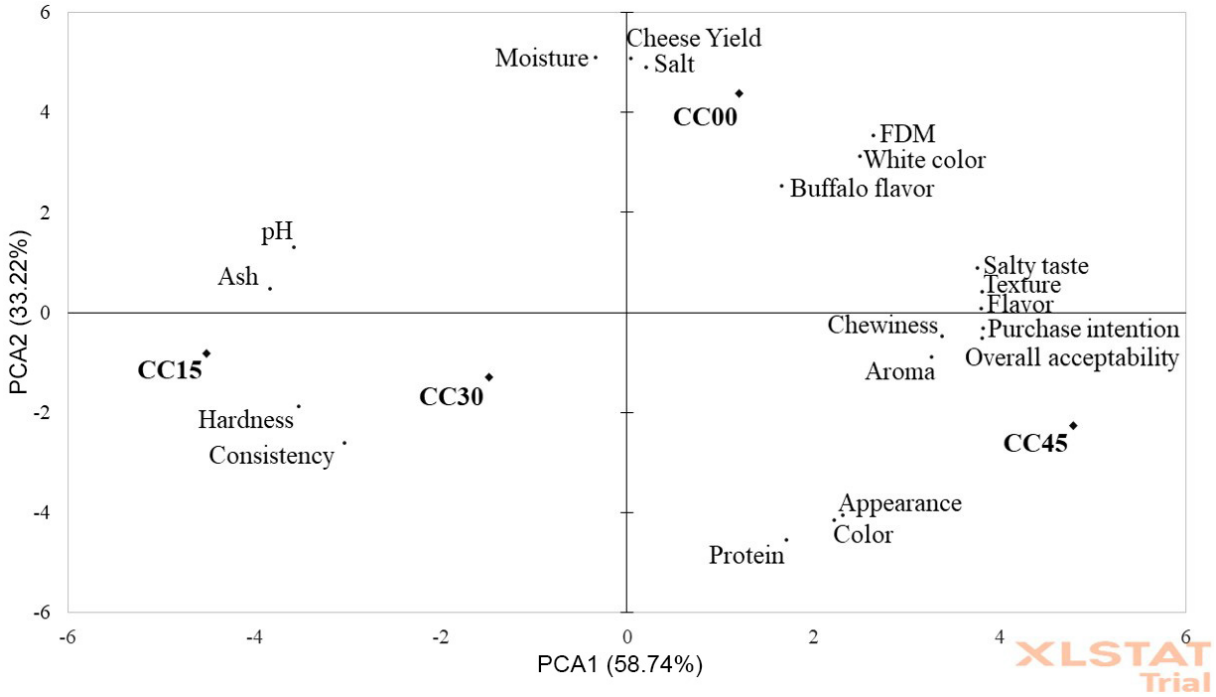


Figure 1. Principal Component Analysis (PCA) from the physicochemical characteristics and sensory attributes of Brazilian semi-hard buffalo cheese mixed with different cow milk ratios.

The flavor had a positive correlation ($p < 0.05$) with salty taste leading to positive results in overall acceptability and purchase intention, while color and appearance had an enormously positive association with each other, and all these attributes approximate to CC45. The sensory perception is considered an essential attribute and provides information about the quality, flavor, and maturity of cheeses, decisive in stimulating consumers (Khattab et al., 2019). The hardness had more impact in CC15 with strictly negative associated texture and can be observed by an obtuse angle between them. In fact, pH presented a negative ($p < 0.05$) correlation with aroma and flavor attributes, and ash content negatively affected the sensory attributes such as texture, flavor, salty taste, and, indirectly, overall acceptability and purchase intention.

4 Conclusion

According to the consumers, the mixtures containing 70% buffalo milk and 30% cow milk (CC30) and mainly 85% buffalo milk and 15% cow milk (CC15) decreased the semi-hard buffalo cheese quality attributes flavor and texture. Nevertheless, semi-hard buffalo cheese made with 55% buffalo milk and 45% cow milk (CC45) presented higher salt levels and acidity. They were considered the best formulation by improving most sensory attributes, including overall acceptability and purchase intention, without affecting aroma and flavor. Therefore, the buffalo and cow milk mixture can be a crucial technological strategy for the buffalo dairy industry.

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