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Effect of high somatic cell counts on the sensory acceptance and consumption intent of pasteurized milk and *coalho* cheese

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Abstract

Our aim was to evaluate the sensorial acceptance and consumption intent of pasteurized milks and *coalho* cheeses produced with milk with low (80,000 cells/mL) and high (480,000 cells/mL) somatic cell count (SCC) level. Low SCC pasteurized milk (LCC) obtained statistically higher scores on the aroma, consistency, flavor and overall liking attributes in comparison with high SCC pasteurized milk. LCC mean scores for all attributes were statistically higher than high SCC *Coalho* Cheese. High SCC in raw milk has a detrimental effect on the quality of pasteurized milk and *coalho* cheeses as it presented lower sensory acceptance, failing to meet the consumer's desired expectations.

Keywords: consumer; dairy product; mastitis; raw milk.

Practical Application: Monitoring milk and cheese quality adds value to the entire production chain and increases food safety for consumers, as well as being directly related to competitiveness, profitability, maintenance and market success. This study brings a significant contribution in verifying the influence of somatic cell count on the sensory acceptance and consumption intent of pasteurized milk and *coalho* cheese.

1 Introduction

Mastitis is a common disease in dairy herds caused by a diverse group of bacterial pathogens. It is an inflammatory condition which causes economic damage to the dairy chain by reducing the production and modifications of the main components in milk (Rangel et al., 2014; Ruegg, 2018). Increased somatic cell count (SCC) in milk is associated with subclinical mastitis, increased enzyme activity which are potentially harmful to milk constituents (Corassin et al., 2013; Alhussien & Dang, 2018). Thus, deleterious effects from the high SCC in milk reflect on the characteristics and quality of the dairy products, depreciating the texture, industrial yield, sensorial quality and the shelf life (Corassin et al., 2013; Ismail & Nielsen, 2010).

This occurs due to the action of lipases originating from the SCC on triacylglycerides, resulting in the appearance of sensory defects such as rancidity. Even after pasteurization, milk with high SCC shows an increase in lipolytic activity, and the occurrence of rancidity can be identified in sensory analysis tests (Santos et al., 2007) when the free fatty acid concentrations are greater than 0.200 meq/kg of milk (Santos et al., 2003), and these defects were also additionally related to a higher proteolysis rate in milk with high SCC (849,000 cell/mL). It is possible to increase the shelf life of refrigerated pasteurized milk when using milk with low SCC (45,000 cell/mL) associated with care during handling and refrigeration, avoiding the development of rancidity or bitter taste due to the release of peptides mainly originating from alpha S1- and beta-casein, which can lead to important sensory changes in milk (Ivanov et al., 2020).

According to Fernandes et al. (2008a), a high SCC in raw milk increases the proteolysis of UHT milk as a consequence of beta-casein degradation, which can negatively affect product quality and lead to a lower nutritional value. Proteolysis associated with increased SCC in milk promotes the breakdown of casein micelles, which can contribute to increased susceptibility of ultra-high temperature (UHT) milks to gelation, which is a major concern for the dairy industry (Fernandes et al., 2008b). The main effects of SCC in dairy products include lower cheese yield, fat and protein loss, high humidity, shorter shelf life and lower sensory quality in minas frescal and mozzarella cheeses (Andreatta et al., 2007, 2009), greater lipolysis, free fatty acids and decreased shelf life in yogurt (Fernandes et al., 2007; Ivanov et al., 2020), and greater proteolysis in pasteurized milk (Ma et al., 2000). In the case of cream manufacturing,

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Coelho et al., (2017) indicate that the product may be a technological alternative for using milk with a high SCC, since no significant microbiological and physicochemical changes were detected during storage for 30 days.

Coalho cheese (or rennet cheese) is traditionally produced in northeastern Brazil and consumed throughout the country. It is obtained from the enzymatic coagulation of bovine milk, producing a semi-cooked or cooked mass with medium to high humidity and 35 to 60% of fat in the total solids (Brasil, 2001) and commercialized fresh or with a maturation period of up to 10 days. *Coalho* cheese has a semi-hard or elastic consistency, compact and soft texture, uniform yellowish white color, slightly acidic mild flavor, salty or seasoned, thin crust and without cracks and small holes/bubbles or without (Brasil, 2001).

Considering the lack of studies regarding the effect of high SCC on *coalho* cheeses sensory quality, we aimed to verify the influence of somatic cell count on the sensory acceptance and consumption intent of pasteurized milk and *coalho* cheese among untrained panelists.

2 Materials and methods

The project was approved by the Research Ethics Committee involving human subjects of the Universidade Federal do Rio Grande do Norte (UFRN), under license number CAAE - 67250417.9.0000.5537. No animal experiments were performed.

2.1 Collection of the raw milk

Raw milk collection, milk processing and cheese production were conducted at the dairy industry of the Association of small cattle breeders of Sertão de Angicos (APASA), in the semi-arid region of Rio Grande do Norte, northeastern Brazil. The climate of the region is BSh type according to the Köppen-Geiger climate classification, being arid with dry and hot air (Peel et al., 2007).

Low SCC ("L") and High SCC ("H") milk samples were collected from different bulk cooling tanks. Each bulk cooling tank received milk production from 10 farms. The L bulk cooling tank received milk with SCC≤ 100,000 cells/mL and H bulk cooling tank received milk SCC≥ 300,000 cells/mL. Cooling tanks are constantly kept at 4 °C. A sample of raw milk (40 mL) was collected directly into each storage tank for analysis of somatic cell counts and chemical composition (Table 1). According to Revilla et al. (2009), the use of bulk tank milk is more realistic from an industrial point of view.

The definition of "low SCC" and "high SCC" were based on Brazilian standards for raw milk (Brasil, 2018).

2.2 Laboratory analysis of raw milk

The milk SCC was determined using the fluoro-opto-electronic counter method in a SomascopeTM (ISO 13366, IDF 148-2, Delta Instruments, Drachten, Netherlands) (International Dairy Federation, 2006) and the result was expressed as one thousand somatic cells per mL.

The fat, protein, lactose, total solids, and casein percentages were determined by the Fourier transform infrared (FTIR) absorption method in a LactoScope® (ISO 9622, IDF 141C, Delta Instruments, Drachten, Netherlands) (International Dairy Federation, 2013).

The total bacterial count (TBC) was analyzed to confirm milk bacterial counts. TBC analysis was carried out in a laboratory integrated to the Brazilian Milk Quality Network (RBQL) to confirm the isolated effect of somatic cell count on milk and cheese. TBC was obtained by flow cytometry through a Bactocount® electronic counter [Bentley Instruments Inc., ISO 21187/International Dairy Federation - IDF- 196], with the results expressed in number of colony forming units per mL. The counts were below the bacterial load required to be associated with lipolysis and proteolysis in milk and cheese.

2.3 Milk pasteurization and coalho cheese production

L and H raw milk samples underwent HTST (high temperature, short time) pasteurization in plate heat exchangers at 72-75 °C for 15 seconds. The pasteurized samples were then forwarded to cheese production after the heat treatment.

Samples (10 liters) of Low SCC Pasteurized Milk (LPM) and High SCC Pasteurized Milk (HPM) were collected and kept under cold storage (below 4 °C) for seven days until sensory analysis.

The *coalho* cheese was obtained by enzymatic coagulation of milk following the procedures adopted by the dairy plant as described in the flowchart (Figure 1). Samples (150 liters) of each L and H milks were sent to cheese production immediately after pasteurization. Five kilograms of vacuum-packed Low SCC *Coalho* Cheese (LCC) and High SCC *Coalho* Cheese (HCC) were randomly reserved and kept under cold storage (between 1 °C and 4 °C) for 20 days until sensory analysis. Cheeses were also wrapped in a black plastic bag to prevent oxidation of the components by light, according to the methodology adapted from Ma et al. (2000).

Microbiological analyzes were carried out to verify the sanitary conditions of the processed products as regulated by the current legislation (Brasil, 2001, 2003).

2.4 Sensory analysis of pasteurized milk and coalho cheese

Untrained participants (n = 203, aged between 19 and 60 years, male and female) were recruited among students,

Table 1. Chemical composition of raw milk with low and high somatic cell count (SCC) levels.

Milk composition	Level	
	Low SCC	High SCC
Somatic Cell Count (cells.mL^{-1})	80,000	480,000
Fat (g.100 g^{-1})	3.74	3.41
Protein (g.100 g^{-1})	3.07	3.00
Casein (g.100 g^{-1})	2.38	2.26
Lactose (g.100 g^{-1})	4.72	4.61
Total dry extract (g.100 g^{-1})	12.34	11.84
Defatted dry extract (g.100 g^{-1})	8.44	8.54

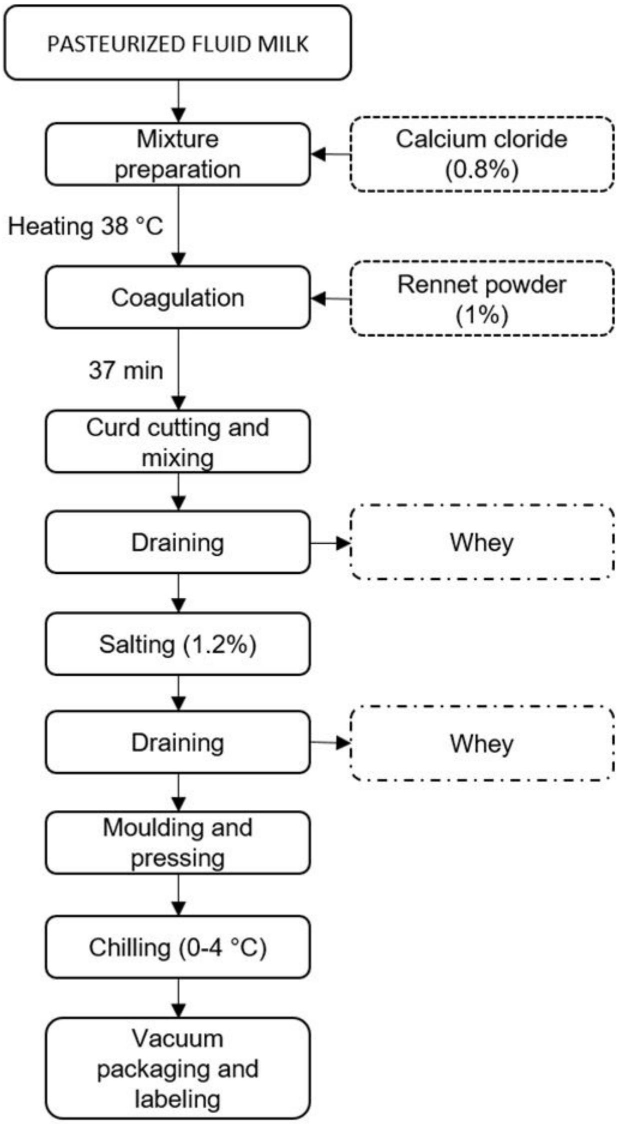

Figure 1. *Coalho* cheese production flowchart.

professors and employees of Escola Agrícola de Jundiaí, UFRN, where the sensory tests were conducted in order to investigate whether SCC levels resulted in remarkable differences in the pasteurized milks and *coalho* cheeses. Volunteers were chosen after filling out a questionnaire on their consumption habits of dairy products. Pasteurized milk analyses were carried out with 103 participants (52 men and 51 women) and *coalho* cheeses were evaluated by 100 participants (52 men and 48 women). The panelists declared themselves regular consumers of milk and dairy products (at least 2-3 times a week) and reported no allergies or intolerance to milk components.

The tests were conducted on two different days: one for milk samples, and another for cheese samples. Sensory tests were conducted with single batches of each sample (LPM, HPM, LCC and HCC) to exclude errors related to composition variation in different batches. Tests were carried under standard white light and temperature conditions (20 °C). Prior to each assessment, the subjects were informed about the task for each of the conducted method. Mineral water and salt cracker biscuits were available as neutralizers between samples in order to avoid carryover effects.

The milk (25 mL) and cheese (25 g) samples intended for testing were kept in isothermal boxes with ice until they were served to the participants in 50 mL white disposable plastic cups. Samples were coded with numbers composed of three random digits using a random number table.

First, the panelists performed the triangular test according to ISO 4120 (International Organization for Standardization, 2004). Each participant received three samples with random codes and were informed that two of them were the same and one was different, and they were asked to identify the one that was different. The number of participants that matched the identification of the different samples was quantified to indicate if there was a perceptible difference between the product obtained from milk with low SCC and high SCC.

Then, the acceptance test was executed using the 9-point hedonic scale (ranging from "dislike extremely" to "like extremely"), in which the judge expressed their degree of liking or disliking the product in relation to appearance, aroma, consistency (fluid milk) or texture (cheese), flavor and overall liking.

The consumption intent was assessed using a structured 7-pont scale (ranging from "I would always drink/eat" to "I would never drink/eat"). Acceptability Index (AI) was calculated through the equation AI (%) = Y/Z x 100; where, Y = average score obtained in the sample attribute; and Z = maximum score given to the sample attributes. The cut-off criterion used for the index to be considered of good acceptance was equal to or greater than 70% (Queiroz & Treptow, 2006).

2.5 Statistical analysis

A randomized complete block (RCB) experimental design was implemented, in which the treatments were performed with low SCC samples (80,000 cells/mL) and high SCC samples (480,000 cells/mL) and the blocks were the participants. The data were evaluated according to the triangular test score and the difference between the values was analyzed using the chi-squared test (Dutcosky, 2013).

Statistical analyses of triangular test considered a binomial distribution model and the minimum number of correct responses needed to conclude that a perceptible difference exists was calculated with $\alpha = 0.001$ (International Organization for Standardization, 2004). Means and significance levels for degree of difference between sample attributes and consumption intent were calculated in Microsoft Office Excel® using the paired Student's t-test. Differences were considered significant at $P \leq 0.05$.

3 Results

The differences between milks with low and high SCC were perceived by most participants in the triangular test results, as 59 untrained volunteers identified the different sample, exceeding the minimum required (50 judges) to establish a significant difference ($P < 0.001$).

LPM obtained higher scores on the attributes of aroma, consistency, flavor and overall liking in the sensory acceptance test. The only sensory attribute in which no significant statistical difference ($P< 0.05$) was observed in this test was appearance (Figure 2).

LPM attributes reached acceptability index above 70%, while only appearance, consistency and overall liking of HPM achieved good values (Table 2). LPM indexes for all attributes (appearance, aroma, consistency, flavor and overall liking) were superior than HPM ones.

There was also a statistical difference ($P< 0.001$) in relation to the consumption intent of pasteurized milk. The mean LPM score was 5.26 ± 1.36, while HPM obtained 4.58 ± 1.25. The distribution of the panelists' consumption intent is shown in Figure 3. These findings indicate that there was an effect of the SCC levels on the sensory characteristics of pasteurized milk and consequently its acceptance and consumption intent by untrained volunteers, in which milk with low SCC was better evaluated.

A statistically significant difference ($P< 0.001$) was observed for the *coalho* cheese evaluation, demonstrating that the sensorial differences related to SCC can be easily perceived by untrained panelists. A total of 87 volunteers recognized the different sample (the minimum number required to reach statistical significance was 48), meaning that differences between L and H milk were perceptible.

LCC obtained higher mean scores ($P< 0.05$) than HCC for all analyzed parameters in the evaluation of the *coalho* cheeses attributes (Figure 4). Flavor was the attribute with the higher score difference between LCC and HCC.

Acceptability index of all LCC attributes were above 70%. Aroma and flavor of HCC achieved the lowest values regarding the results observed for high SCC pasteurized milk, being below the minimum required value (Table 3).

The data showed that 40% of the participants "would always eat" the cheese produced with the low SCC milk, while only 16% of the participants "would always eat" the cheese obtained from milk with high SCC (Figure 5), thus demonstrating higher intention of the panelists to have *coalho* cheese elaborated from low SCC milk inserted into in their consumption habits. The mean LCC score (5.60 ± 1.49) was significantly higher ($P< 0.001$) than the mean HCC score (4.50 ± 1.57).

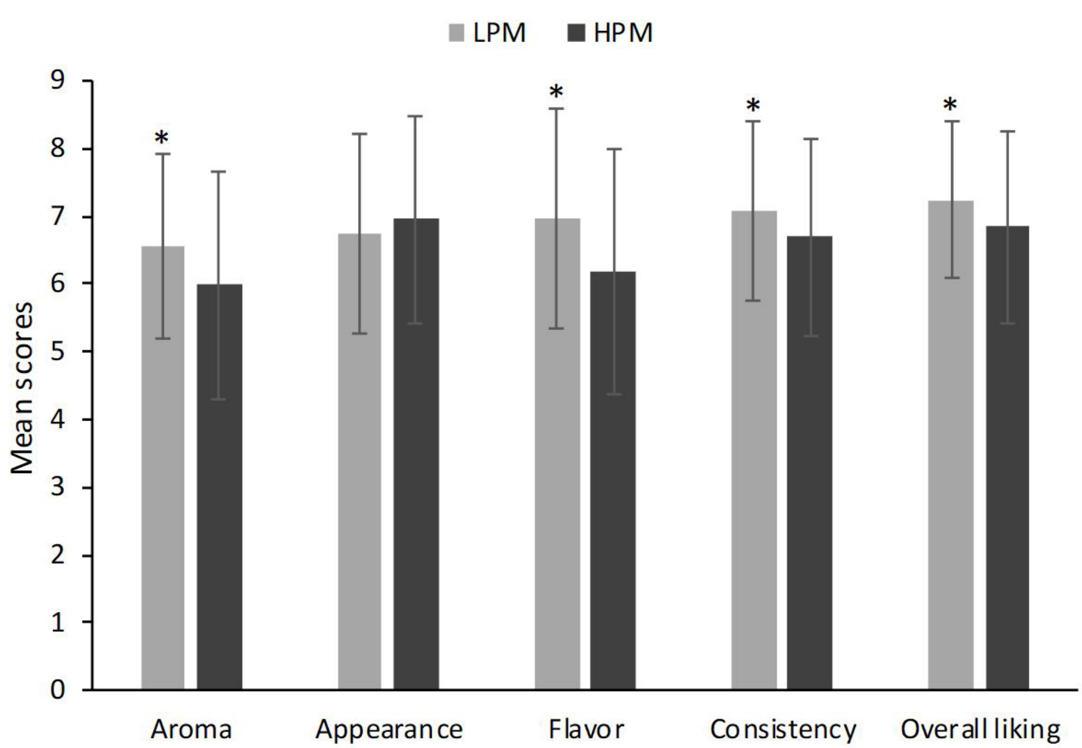

Figure 2. Sensory evaluation of pasteurized milk obtained from raw milk with low (80,000 cells/mL) and high (480,000 cells/mL) somatic cell count. (n=103). LPM: Low somatic cell count pasteurized milk; HPM: High somatic cell count pasteurized milk. *Statistically different ($P< 0.05$).

Table 2. Acceptability Index (%) of pasteurized milk obtained from raw milk with low (80,000 cells.mL^{-1}) and high (480,000 cells.mL^{-1}) somatic cell count (SCC).

Sample	Appearance	Aroma	Consistency	Flavor	Overall liking
LPM	84.87	72.82	78.64	77.35	80.37
HPM	77.35	66.56	74.33	68.61	76.05

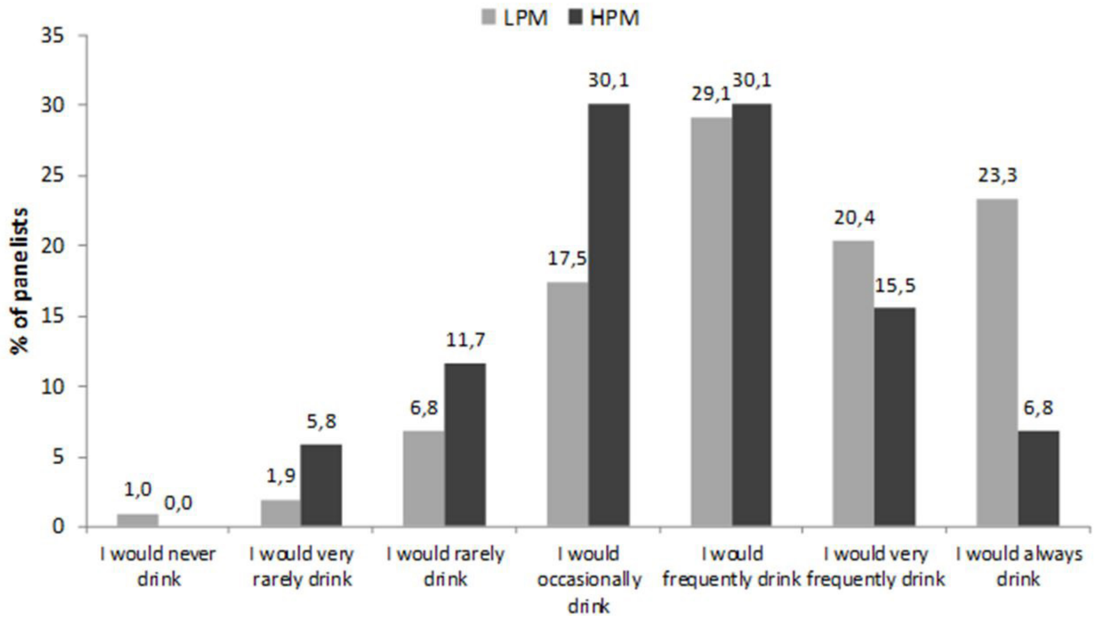

Figure 3. Consumption intent of pasteurized milk obtained from raw milk with low (80,000 cells/mL) and high (480,000 cells/mL) somatic cell count (n=103).

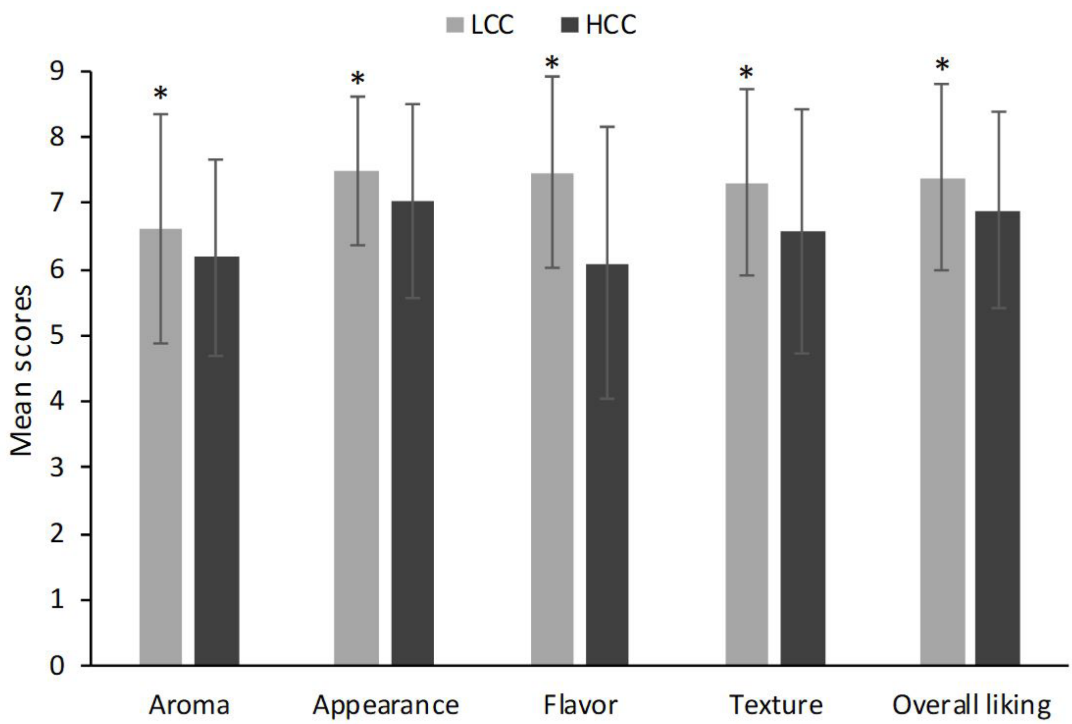

Figure 4. Sensory evaluation of *coalho* cheese produced from milk with low (80,000 cells/mL) and high (480,000 cells/mL) somatic cell count (SCC) (n=100). LCC: *coalho* cheese produced from milk with low somatic cell count; HCC: *coalho* cheese produced with milk with high somatic cell count. *Statistically different (P<0.05).

4 Discussion

Aroma and taste of HPM were the sensory attributes with the worst evaluation (5.99 and 6.17, respectively), between "indifferent" and "slightly liked", demonstrating the possible enzymatic action on the protein degradation and production of volatile compounds, which reduces milk quality. LPM consistency (7.08) and the overall liking (7.23) were in the "moderately liked" scales, evidencing that a smaller number of somatic cells results in better sensory acceptance of the milk sample. In these circumstances milk with high SCC potentially loses nutritional

Table 3. Acceptability Index (%) of *coalho* cheese produced with raw milk with low (80,000 cells.mL^{-1}) and high (480,000 cells.mL^{-1}) somatic cell count (SCC).

Sample	Appearance	Aroma	Texture	Flavor	Overall liking
LCC	83.33	73.67	81.33	82.89	82.11
HCC	78.10	68.67	73.00	67.78	76.67

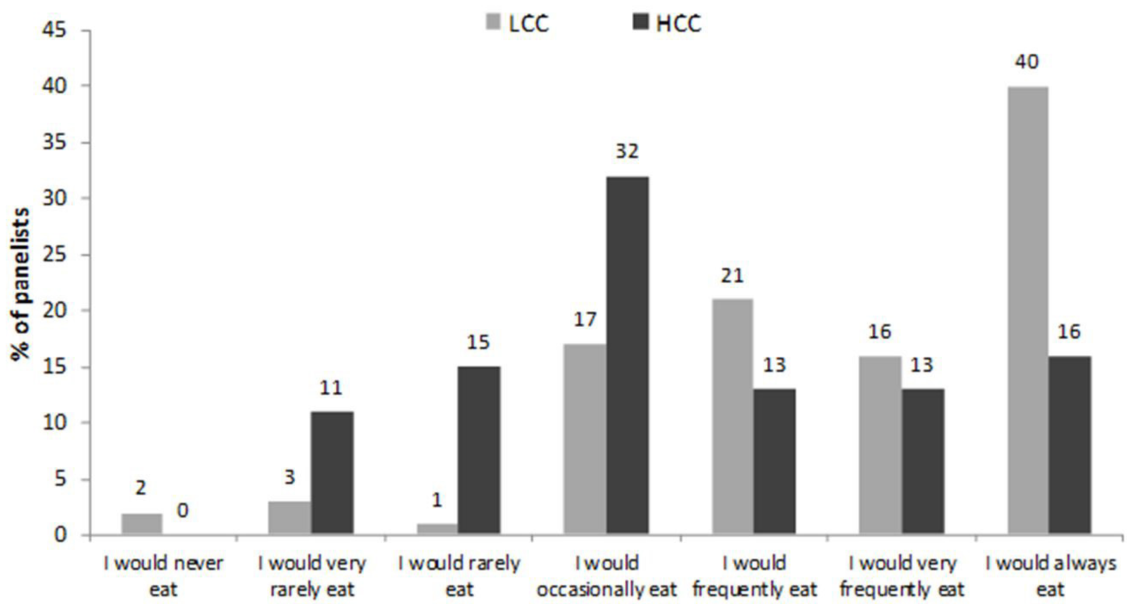

Figure 5. Consumption intent of *coalho* cheese produced with milk with low (80,000 cells/mL) and high (480,000 cells/mL) somatic cell count (n=100).

and sensorial quality even after heat treatment. The implications of this negative effects influenced the consumption intent, which was lower for HPM.

Those effects were previously reported by Ma et al. (2000) when panelists, intensively trained, detected and described defects caused by high SCC in cow milk. Differences between low and high SCC milk were even more remarkable after 21 days of cold storage. Authors relate comments at the day 1 of analysis, such as "without normal milk aroma", "lacks freshness", "unclean" and "less sweet than normal milk" to unknown volatile compounds. Although untrained, our panelists (representing potential consumers) evaluated products after 7 days of storage and were also capable of distinguish the samples. Ivanov et al. (2020) also reported the appearance of defects in the taste of yogurts obtained from milk with high SCC and attributed it to the high butanoic and hexanoic acid content. In addition, he also emphasized that somatic cells are a source of lipases, which are released into milk during processing and storage.

Pasteurized or UHT milk obtained from raw milk with high SCC content (from 500.000 cells/mL) is characterized by developing flavor defects. Some of the consequences are the proteolysis of milk due to the degradation of beta-casein, and lipolysis which can negatively affect the quality of the product and lead to a lower nutritional value (Fernandes et al. 2008a; 2008b; Santos et al., 2007). These defects may be associated with the plasmin levels, the endogenous enzyme of milk, and its inactive form plasminogen, which have their proteolytic activity associated with SCC (Ismail & Nielsen, 2010) and affects stability and taste of the fluid milk. In addition, other thermostable proteolytic enzymes remain active after the milk pasteurization or sterilization process (Corassin et al., 2013; Alhussien & Dang, 2018).

A significant difference was also identified in all sensory attributes of the *coalho* cheese produced with milk with low and high SCC, which could be associated (among other factors) with a greater amount of enzymes produced by somatic cells, resulting in a negative impact effect on texture and flavor (Rogers & Mitchell, 1994; Johansson et al., 2017). Plasmin degrades especially α-casein and β-casein fractions, which are the main milk proteins involved in the coagulation process and constitute fundamental importance in cheese production (Ismail & Nielsen, 2010).

In our study, the milk sample with high SCC presented 5% less casein in comparison with LPM, which might be involved with the impaired sensory acceptance of the cheese sample HCC. Lower casein concentration and increased serum proteins in high SCC milk can cause negative effects on cheese production results, mainly by alterations in organoleptic properties, coagulation time, curd formation, humidity and clot stiffness, thereby reducing industrial yield and producing texture defects (Bobbo et al., 2016).

As previously mentioned, there is increased blood component flow to the milk during mastitis (Alhussien & Dang, 2018), among which are antimicrobial substances such as immunoglobulins and lactoferrin, which may interfere in the development of lactic cultures, thereby compromising milk coagulation and consequently texture and taste characteristics of dairy products (Coelho et al., 2012).

In relation to the fat component in the milk with high SCC, an increase in the lipolysis rate commonly occurs caused by lipases originated from somatic cells or bacteria (Gargouri et al., 2013). Therefore, there is an increase in short chain fatty acids (caproic, caprylic, capric and butyric) which contributes to the occurrence of sensorial defects such as rancid taste and odor in dairy products (Chen et al., 2003). These chemical modifications could contribute to the lower scores recorded for high SCC pasteurized milk and cheese.

Rogers & Mitchell (1994) compared cheese made from milk with different SCC categories and verified that cheese made with higher SCC obtained lower technological performance (higher moisture, increased coagulation time, reduced yield), as well as sensory defects in texture and taste (Andreatta et al., 2007, 2009). Another study involving a sensory evaluation of Mozzarela cheeses prepared with cow milk with three different levels of SCC (low SCC: < 200,000 cells/mL, intermediate SCC: ≈ 400,000 cells/mL and high SCC: > 800,000 cells/mL), concluded that the increase of SCC did not impair sensory aspects. However, the technological feature of malleability is increased in high SCC Mozzarella cheese (Andreatta et al., 2007).

Overall acceptance, body and texture of goat semisoft cheese were also negatively affected by high SCC (> 1,000,000 cells/mL) (Chen et al., 2010). However, the influence of high SCC in ewes'-milk cheeses (from three different breeds) on sensory characteristics was only significant for the Castellana cheese type. This suggests that breed rather than SCC levels influences acceptability to a greater extent, probably related to differences in the milk chemical composition (Revilla et al., 2009).

The extent of the impact of high SCC on cheese sensory attributes will vary with the type of product and different ripening patterns among cheese varieties. Our results suggest that even within the limits established by Brazilian agencies, high SCC cow milk can contribute to impair technological and sensory quality of dairy products.

An additional sensory characterization in terms of projective methods and descriptive tests (Oliveira et al., 2017; Torres et al., 2017; Judacewski et al., 2019; Rodrigues et al., 2020; Soares et al., 2020) such as a quantitative descriptive analysis (QDA) should be performed for a complete sensory analysis in future studies, and can be promising because it is a method to qualify the type and quantify the intensity of sensory properties immediately after sensory detection. The temporal dominance of sensations (TDS) has been widely used as a temporal descriptive technique to provide information on the sequence and duration of dominant sensations (Galmarini et al., 2017). The combination of QDA and TDS in a sequential approach can be used in a commercial context and enables a more complete profile of the product category (Ng et al., 2012). In a study by Silva et al. (2018), the TDS methodology was useful in characterizing the taste of cheese with reduced sodium, providing information on the influence of formulation variables which were not provided by QDA, but can be a very complete tool for the application of sensory tests of milk and dairy products such as cheese with low, medium and high somatic cell counts.

5 Conclusion

To the best of our knowledge, this is the first study showing the effects of high SCC in *coalho* cheese, a traditional Brazilian dairy product. Somatic cell count determined perceptible sensory differences in pasteurized milk and *coalho* cheese obtained from low (80,000 cells/mL) and high SCC (480,000 cells/mL) milk. High levels of somatic cells had a detrimental effect on the sensory acceptance and consumption intent of both products.

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