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Development and characterization of two novel formulations of Labneh cheese of sheep's milk

Emiliane Rodrigues GAVIÃO[1], Félix Roman MUNIEWEG[2], Marcela CZARNOBAY[3], Amanda DILDA[4], Lenita de Cássia Moura STEFANI[5]*, Cássia Regina NESPOLO[6]

Abstract

The growth of dairy sheep farming in Brazil combined with consumer´s preference for concentrated yogurts and the search for innovative products with different flavors and textures demonstrate the opportunity for diversification of sheep milk derivatives. The objective of this study was to develop two novel formulations of Labneh cheese made of sheep's milk and to verify their shelf life considering microbiological and physical-chemical quality under refrigeration storage. Formulations L1 and L2 were prepared using a similar protocol with pressing times of 4 and 3 hours respectively, and this difference caused little influence on the parameters evaluated, showing no need for this additional time. Both formulations had the desired spreadability characteristic and the final products showed moisture and fat content classified as very high moisture and semi-fat cheeses according to the Brazilian legislation. The microbiological counts in L1 and L2 after 150 days of cold storage were within legal limits for thermotolerant coliforms, *Staphylococcus aureus*, *Salmonella* sp. and *Listeria monocytogenes*. The satisfactory results in the microbiological and physical-chemical evaluations demonstrated that the Labneh formulations and processing method were efficient to produce a stable product of good quality, indicating that it can be commercialized to a specific niche market.

Keywords: microbiological quality; physical-chemical characterization; semi-fat cheese; ewe's milk.

Practical Application: The development of a sheep's milk Labneh cheese and its spreadable presentation brings a new product to the dairy industry. The elaboration of the processing protocols and the relative microbiological and chemical stability during the cold storage of the products demonstrate the feasibility of being produced in small dairy industries. The formulations of Labneh sheep's milk cheese developed contribute to innovation and contemplate the trends of the Brazilian consumers.

1 Introduction

Labneh cheese is an intermediate product between fermented milk and high humidity cheeses made of yogurt or other fermented milk, such as *kefir*, with partial whey removal (Atamian et al., 2014; Rocha et al., 2014). This product is originated in the Middle East, currently also called concentrated yogurt or Greek yogurt and it is consumed worldwide due to its high nutritional benefits (Atamian et al., 2014; Jaoude et al., 2010). It features white to cream color, smooth, pasty, semi-solid appearance, smooth consistency and good spreadability, with a mild flavor, which may tend to acid (Ferreira et al., 2012; Rocha et al., 2014). The preference for these yogurts with greater consistency, such as Greek yogurts, is a consumer trend in the Brazilian market (Siqueira, 2019).

Dairy sheep farming is an activity with approximately twenty years in Brazil (Munieweg et al., 2017; Santos et al., 2016), a country that has a sheep herd corresponding to 23% of the total of the American continent (Food and Agriculture Organization of the United Nations, 2018), which 21% of this in located in the South of Brazil (Instituto Brasileiro de Geografia e Estatística, 2018). Sheep milk is usually not consumed in its natural form but used to make cheeses and yogurts, due to its high levels of total soluble solids, good acceptance by consumers, and the commercialization value of the products (Balthazar et al., 2017, 2019a, b; Munieweg et al., 2017; Pellegrini et al., 2013), which can be an income opportunity for small and medium producers (Santos et al., 2016). In addition, the Brazilian consumer market has tried other types of milk, such as sheep, goat and buffalo, and signaled the search for innovation, functional products and new flavors and textures from the dairy industry (Balthazar et al., 2019b; Siqueira, 2019).

The transformation of milk into yogurt involves fermentation for yogurt production with the elimination of whey to obtain concentrated yogurt, originally developed to prolong yogurt shelf life (Atamian et al., 2014; Jaoude et al., 2010). Sheep milk has high concentration of total solids and the average composition of raw sheep milk produced in Southern Brazil ranges from 5.5 to 6.0% of protein, 5.9 to 7.3% of fat, 0.7 to 0.9% of ashes and 17.1 to 17.5% of total solids (Munieweg et al., 2017; Nespolo & Brandelli, 2012), resulting in high yields in the

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[1]*Universidade Federal do Pampa – UNIPAMPA, Campus Itaqui, Itaqui, RS, Brasil*
[2]*Universidade Federal do Pampa – UNIPAMPA, Campus Uruguaiana, Uruguaiana, RS, Brasil*
[3]*Instituto Federal de Educação, Ciência e Tecnologia – IFRS, Bento Gonçalves, RS, Brasil*
[4]*Curso de Zootecnia, Universidade do Estado de Santa Catarina – UDESC, Chapecó, SC, Brasil*
[5]*Departamento de Ciência e Tecnologia, Centro de Educação a Distância – CEAD, Universidade do Estado de Santa Catarina – UDESC, Florianópolis, SC, Brasil*
[6]*Universidade Federal do Pampa – UNIPAMPA, Campus São Gabriel, São Gabriel, RS, Brasil*
*Corresponding author: lenita.stefani@udesc.br

production of Labneh cheese. In addition, the production of sheep milk in the Southern region of Brazil and the constant innovation of the dairy market determine the need for diversification of the derivatives of this milk. Therefore, the objective of this study was to develop two formulations of Labneh cheese from sheep milk, and to evaluate their shelf life considering microbiological and physical-chemical characteristics.

2 Materials and methods

2.1 Production of Labneh cheese of sheep's milk

Labneh cheese was produced in a commercial cheese plant located in Southern Brazil using milk of Lacaune sheep. Figure 1 shows a flowchart for the production process of Labneh cheese. Sheep milk with 6.5% of fat was pasteurized and subjected to lactose hydrolysis with the addition of the lactase enzyme (Lactlow L), which is a standard step in this dairy industry. Fermentation occurred by adding a mixed heterofermentative milk culture (Granoferm 200). After the fermentation period, the obtained mass was pressed for partial removal of the serum in round forms, in a horizontal pneumatic press (Globoinox), at a pressure of 2 kgf. Two formulations with different pressing times were developed: formulation called L1 with pressing time of four hours and formulation called L2 with pressing time of three hours. The formulations were packed in 100 g plastic cups, closed by heat sealing and labeled accordingly.

2.2 Monitoring the shelf life of Labneh cheese

Samples of Labneh cheeses were transported to the laboratory under refrigeration and storage inside a refrigerated chamber at 5 °C ± 2.5 °C. Sampling took place in the initial time and every thirty days, up to 120 days of cold storage for physical-chemical analyzes and up to 150 days for microbiological analyzes. Three samples of each formulation of Labneh cheese were collected at each time of analysis.

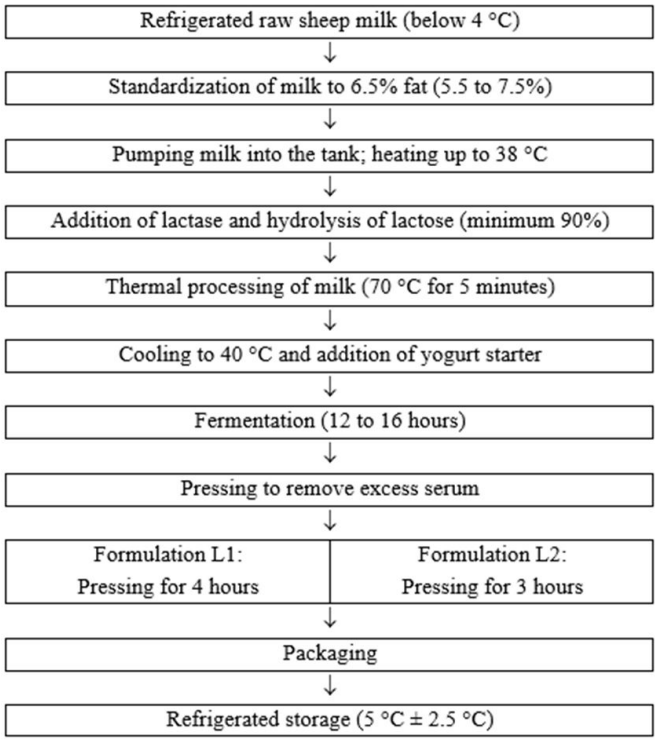

Figure 1. Flowchart of production of sheep's milk Labneh cheese.

Physical-chemical evaluation included determination of fat, moisture, total protein, acidity in lactic acid and fat in the dry extract, by official methodologies (Brasil, 2017). The water activity (Aw) was evaluated in a device model Aqualab 4TE (Decagon), according to the manufacturer's manual (Meter Group, 2020) and the pH was determined using a pH meter model pg1800 (GGHAKA), with the sample diluted in distilled water (Brasil, 2017). The values of fat and moisture allowed the classification of cheeses, according to the current legislation (Brasil, 1996).

The microbiological evaluation included total and thermotolerant coliforms, total aerobic mesophilic, psychrotrophic, molds and yeasts and coagulase positive *Staphylococcus*, with samplings every thirty days of storage. The evaluation of *Salmonella* sp. and *Listeria monocytogenes* was performed only at the end of the storage period. For coliform evaluation, the multiple tube technique with inverted Durham was used, in series of three tubes. The presumptive test was performed in tubes containing sodium lauryl sulfate broth (Dinamica) and the presence of total coliforms was confirmed using bright green broth 2% lactose bile (Himedia) and incubation at 35 °C for 24-48 hours, while the thermotolerant coliforms were in EC broth (Himedia) incubated at 45 °C for 24-48 hours. The quantification of the most probable number (MPN) was through the Hoskins Table. The counting of total aerobic mesophilic bacteria was performed by plating on Standard Count Agar (PCA) (Oxoid), with incubation at 37 °C, for 24-48 hours. The psychrotrophic count was in PCA (Oxoid) and incubation at 7 °C, for 10 days. For molds and yeasts, the inoculation was on the surface of the Potato Dextrose Agar (BDA) (Oxoid), with incubation at 25 °C, for 5 to 7 days (Brasil, 2017; Silva et al., 2017).

Staphylococcus sp. count was performed using Baird-Parker Agar (Himedia) medium, enriched with 0.01% potassium tellurite and egg yolk, and incubated at 36 °C for 48 hours. After counting the plates, characteristic colonies of *S. aureus* (black with halos) were transferred to the Brain Heart Infusion (BHI) medium (Himedia) and incubated at 37 °C for 24 hours, with subsequent tests for catalase and coagulase. The catalase test was performed with a 3% hydrogen peroxide solution and the conjugated coagulase test used rabbit plasma (Probac) (Silva et al., 2017). Samples for determining the presence of *Salmonella* sp. were pre-incubated at 37 °C for 24 hours, in 0.1% buffered peptide water. Subsequently, the Petrifilm rapid method was used, following the manufacturer's instructions (3M Food Safety, 2013). To determine the presence of *Listeria monocytogenes*, the VIDAS rapid method was used, following the manufacturer's instructions (Biomérieux, 2018).

The values of the microbiological counts were converted into logarithms (log) and the means and standard deviations from the mean were calculated. The data were evaluated using the SigmaPlot 12.0 program, where analysis of variance was applied followed by the Tukey test at the 5% level of significance.

3 Results and discussion

The results of moisture, protein, fat, acidity in lactic acid and fat in dry extract over refrigerated storage are shown in Figure 2. The average moisture content in the samples ranged from 61.53 to 66.23% for formulation L1 and 64.08 to 68.64% for L2 formulation, at different collection times (Figure 2-I). There was a statistically significant difference ($p < 0.05$) only between formulation L1 at 30 days of shelf life and L2 formulation at 60 days, demonstrating that the pressing time had no influence on the moisture content. Considering the Brazilian cheese identity and quality regulation (Brasil, 1996), both formulations of Labneh cheese produced were classified as very high moisture (above 55%), which indicates a higher microbiological risk evidenced due to the need to evaluate a greater number of microbiological contaminants in the product (Brasil, 2001). Other studies with Labneh cheese also indicated higher humidity (76.68%) when using sheep milk (Atamian et al., 2014) as well as 78.6% in a commercial product (Jaoude et al., 2010), much higher values than those of the present study. Likewise, the values observed in Italian Ricotta cheese produced with sheep's milk were also increased by 73.1 and 75.2% (Mancuso et al., 2014). The percentages of moisture described in the literature for different types of sheep's milk cheeses were lower than those found in this study (Hemmatian et al., 2015; Nespolo & Brandelli, 2012; Pellegrini et al., 2013), most of them ripened cheeses. This might be due to the fact that the use of slow acid producing cultures and lower heat temperatures during the cheese processing aid to retain more moisture in cheese curd (Aydinol & Ozcan, 2018). However, in the case of the developed

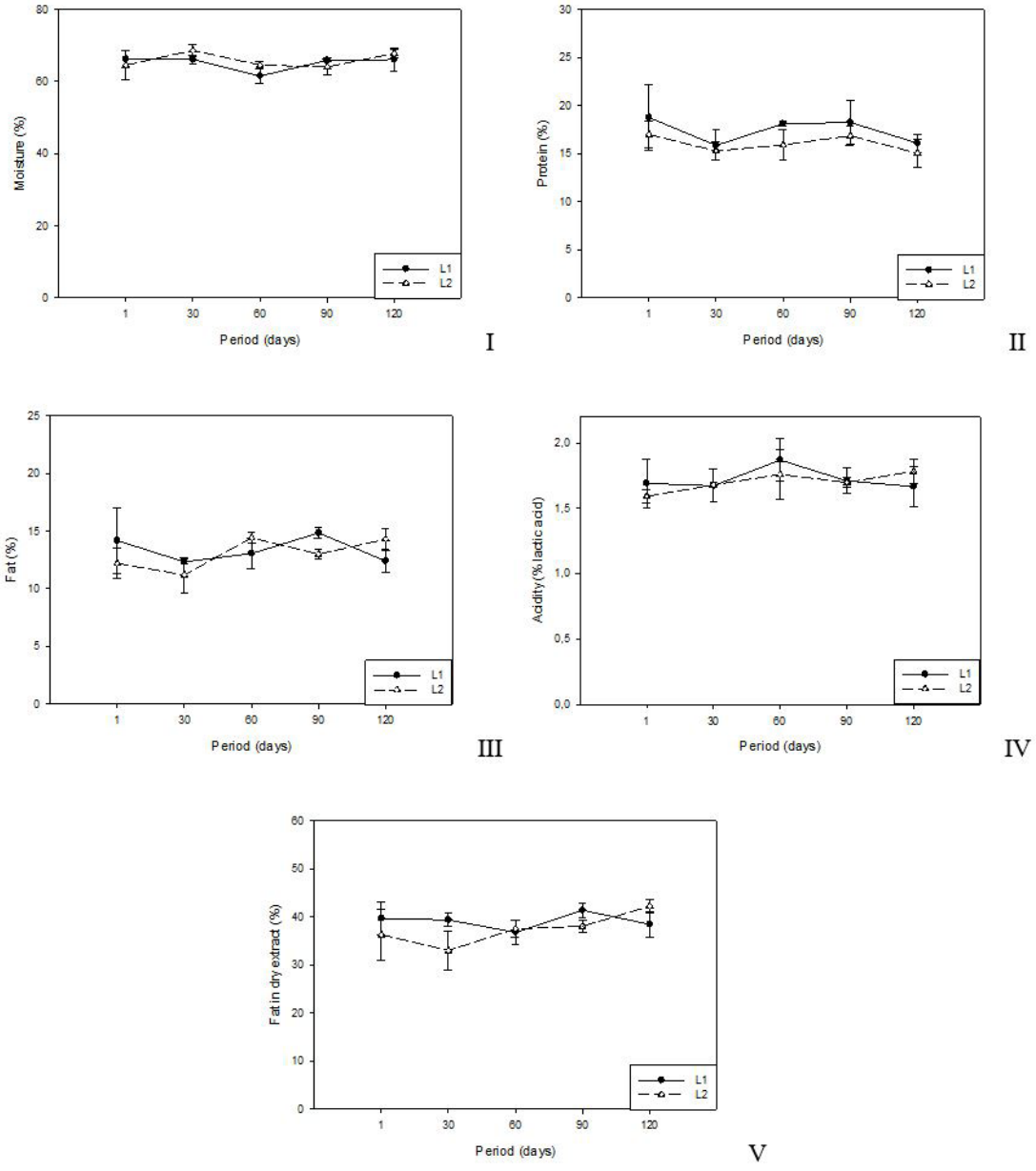

Figure 2. Moisture content (I), protein (II), fat (III), acidity in lactic acid (IV) and fat in the dry extract (V) in the two formulations of Labneh cheese, during refrigerated storage. The continuous line represents formulation L1 (formulation with pressing time of 4 hours) and the dotted line represents formulation L2 (formulation with pressing time of 3 hours).

Labneh formulations, pressing the dough partially removed the moisture, so it is lower than that of other Labneh cheeses (Atamian et al., 2014; Jaoude et al., 2010). The pressing carried out in the formulations (Figure 1) was sufficient to partially remove the moisture, but not excessive to allow the spreadability of the final product.

Regarding protein (Figure 2-II), the mean values ranged between 15.86 and 18.76% for samples L1 and from 15.04 to 16.99% in samples L2, without observing significant differences ($p < 0.05$). Other sheep milk cheeses such as Feta (Nespolo & Brandelli, 2012; Pellegrini et al., 2013) and freshly pressed Fascal (Nespolo & Brandelli, 2012) had similar protein levels. The values were also similar to those indicated for Labneh of sheep milk (Pellegrini et al., 2013) and Labneh cheese in oil (United States Department of Agriculture, 2017a), with 15.98% and 17.86%, respectively, and higher than those observed in another ovine Labneh, with 9.69% (Atamian et al., 2014), and in Labneh spreadable cheese, with 10.71% of protein (United States Department of Agriculture, 2017b).

Fat contents are shown in Figure 2-III, showing high amounts of fat, due to the fact that this cheese is made from milk with about 6.5% fat. The average values remained between 12.33 to 14.83%, in samples L1, and between 11.19 and 14.42% in samples L2, without significant variations ($p < 0.05$). These values were similar to Labneh spreadable cheese (10.71%) (United States Department of Agriculture, 2017b) and Ricotta cheese from sheep milk at times 1 and 14 days, the fat contents were 11.67 and 13.63% (Mancuso et al., 2014), lower than that of Labneh sheep milk cheese produced in Southern Brazil, with 18.81% (Pellegrini et al., 2013), and higher than Labneh sheep milk from Lebanon (5.24%) (Atamian et al., 2014), variations that demonstrate that the fat content depends on the standardization of fat in milk prior to cheese processing. Higher fat values were observed in other sheep milk cheeses produced in Brazil (Nespolo & Brandelli, 2012) and in Poosti raw sheep cheese from Iran (Hemmatian et al., 2015).

The acidity in Labneh cheese (Figure 2-IV) did not show significant differences ($p < 0.05$) between the formulations and the storage periods. The average titratable acidity ranged from 1.67 to 1.87% and 1.59 to 1.78% in formulation L1 and L2, respectively. The organic acid profile of the cow´s milk Labneh cheese was determined in a sample with 12% fat and those with the highest levels, in descending order, were lactic acid, acetic acid, malic acid, propionic acid, citric acid and butyric acid (Aydinol & Ozcan, 2018). Concentrations of organic acids could be improved by increasing the activity of the lactic cultures added to Labneh, however this was not observed during the cold storage of both formulations. Labneh cheese is produced from yogurt and the limits of titratable acidity defined by Brazilian legislation for yogurt vary from 0.6 to 1.5% acidity in lactic acid (Brasil, 2007) and the observed value was higher, due to the removal of whey in the processing and consequent concentration of components, including acids. A study with buffalo and cow's milk yogurts found values between 0.52 and 0.68% of lactic acid (Guimarães et al., 2015) and in *kefir* used in the production of Labneh cheese, with values below 1.0% lactic acid (Rocha et al., 2014). The observed acidity values for Labneh cheeses made from sheep milk were 1.28% (Atamian et al., 2014) and 1.01% (Pellegrini et al., 2013). In another study, the values were between 0.87 and 1.54% of lactic acid in Poosti sheep cheese (Hemmatian et al., 2015) and between 0.42 and 0.86% of lactic acid in type cheese Pecorino Toscano (Pellegrini et al., 2013). The average values of fat in the dry extract in both formulations ranged from 32.99 to 42.21% (Figure 2-IV) and were classified as semi-fat cheeses those with 25.0 to 44.9% of dry extract (Brasil, 1996).

The pH and water activity values during the cold storage of the Labneh cheese can be seen in Table 1. The Labneh cheese had an average pH value between 3.99 and 5.91, with the L2 formulation at 60 days different than all others ($p < 0.05$). Considering that the pH above 4.5 is favorable for the development of pathogenic microorganisms and related to the shorter product life (Forsythe, 2013), only the L2 sample (60) presented this characteristic. The average pH values found in other cheeses were 4.41 in ovine Labneh (Pellegrini et al., 2013), from 4.75 to 6.40 in other sheep's milk cheeses (Nespolo & Brandelli, 2012; Pellegrini et al., 2013), between 5.28 and 5.67 in sheep Poosti cheese (Hemmatian et al., 2015), from 5.96 to 6.54 in sheep Ricotta cheese (Mancuso et al., 2014), between 4.5 and 5.0 in Labneh formulations of bovine milk (Aydinol & Ozcan, 2018) and 4.80 to 5.35 in yogurts produced with different proportions of buffalo or cow's milk (Guimarães et al., 2015), indicating that this is a very variable parameter in dairy products.

Water activity was high for both formulations, with average values between 0.9702 and 0.9877 in samples L1 (day 1) and L2 (day 90), respectively, the only ones with significant differences ($p < 0.05$) (Table 1). This high activity favors the development of pathogenic bacteria, which grow in Aw above 0.85 (Forsythe, 2013). In Ricotta cheese from sheep milk, Aw values were also high, from 0.94 to 0.97 (Mancuso et al., 2014). The parameters humidity (Figure 2-I), Aw and pH (Table 1) indicate the potential for the proliferation of pathogenic and deteriorating microorganisms (Forsythe, 2013) and the results underscored the importance of microbiological monitoring throughout the product's life.

Total counts of total aerobic mesophilic bacteria, molds and yeasts and psychrotrophic are shown in Figure 3. Brazilian

Table 1. Evaluation of pH and water activity (Aw) in the formulations of Labneh cheese during cold storage.

Sample (Period - days)	pH	Aw
L1 (1)	4.34 ± 0.22 ^{bc}	0.9877 ± 0.001^{a}
L1 (30)	3.99 ± 0.013 ^{b}	0.9795 ± 0.004 ^{ab}
L1 (60)	4.10 ± 0.001 ^{bc}	0.9817 ± 0.001 ^{ab}
L1 (90)	4.18 ± 0.013 ^{bc}	0.9793 ± 0.004 ^{ab}
L1 (120)	4.16 ± 0.017 ^{bc}	0.9770 ± 0.001 ^{ab}
L2 (1)	4.07 ± 0.020 ^{bc}	0.9778 ± 0.001 ^{ab}
L2 (30)	4.49 ± 0.131 ^{c}	0.9756 ± 0.001 ^{ab}
L2 (60)	5.91 ± 0.040 ^{a}	0.9801 ± 0.004 ^{ab}
L2 (90)	4.31 ± 0.028 ^{bc}	0.9702 ± 0.131 ^{b}
L2 (120)	4.34 ± 0.048 ^{bc}	0.9786 ± 0.001 ^{ab}

L1 = formulation with pressing time of 4 hours; L2 = formulation with pressing time of 3 hours; values presented as mean ± standard deviation of the mean (n = 3). Same letters in the same column do not differ statistically ($p < 0.05$).

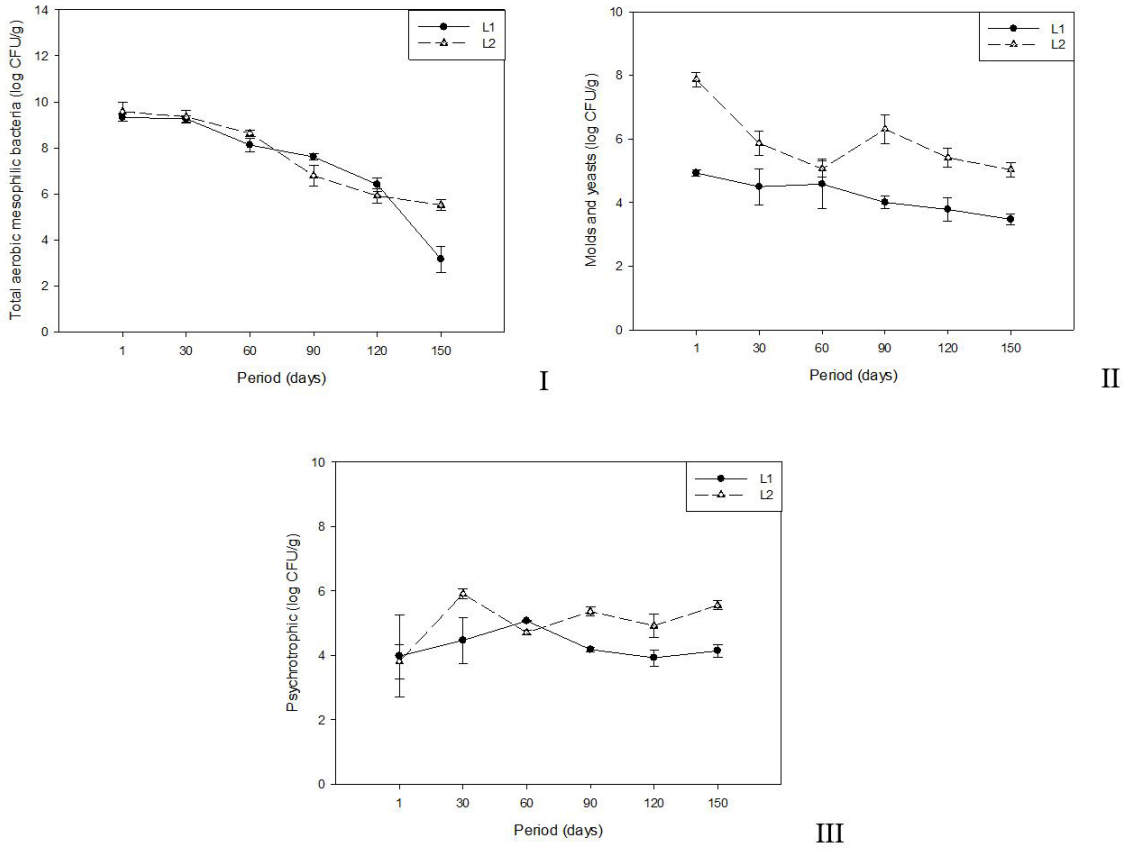

Figure 3. Counts of total aerobic mesophilic bacteria (I), molds and yeasts (II) and psychrotrophic (III) for both formulations of Labneh cheese, during refrigerated storage. The continuous line represents formulation L1 (pressing time of 4 hours) and the dotted line represents formulation L2 (pressing time of 3 hours).

legislation does not specify limits for total aerobic mesophilic bacteria, psychrotrophic, molds and yeasts and total coliforms, however, when there is a high count of these, it means that there was some hygienic-sanitary failure in processing or storage, allowing the development of these groups of microorganisms (Vasek et al., 2013; Forsythe, 2013).

The total aerobic mesophilic count (Figure 3-I) decreased from 9.31 to 3.16 log CFU/g in formulation L1, and from 9.57 to 5.51 log CFU/g for formulation L2. The count in formulation L1 decreased significantly ($p < 0.05$) after 30 days of storage compared to 60, 90, 120 and 150 days; and in formulation L2 after 30 days after storage compared to 60, 90 and 120 days. The total aerobic mesophilic bacteria have an optimum temperature of growth between 30 and 40 °C (Forsythe, 2013), however the Labneh cheese remained stored under refrigeration temperatures, causing a decrease of these bacteria. Total aerobic mesophilic counts at 150 days of storage were significantly different between formulations ($p < 0.05$) and the higher counts found for L2 formulation might be related to the shorter pressing time to eliminate more serum, although this did not significantly affect moisture (Figure 1-I) or water activity (Table 1).

The processing of sheep milk products requires care to avoid the multiplication of unwanted microorganisms, due to the high nutritional value, high water content and pH close to the neutrality (Balthazar et al., 2019a; Munieweg et al., 2017; Tribst et al., 2020), for this reason it is important to monitor the total aerobic mesophilic, an indicator group that may include pathogenic and deteriorating microorganisms (Forsythe, 2013; Tribst et al., 2020). The total aerobic mesophilic count in Labneh of buffalo milk was 7.34 log CFU/g at 15 days of storage (Salem et al., 2013). In Ricotta cheese produced with sheep milk, the total aerobic mesophilic counts ranged from 3.83 log CFU/g on day 1 to 7.56 log CFU/g at 24 days, lower counts than in Labneh formulations, which can be attributed the fact that Ricotta cheese is produced from Pecorino cheese whey and involves additional heating (Mancuso et al., 2014) and causes thermal destruction of microorganisms.

Poosti cheese, produced with sheep milk and packaged in sheepskin, had a high aerobic mesophilic count in the first 30 days of maturation, with 8.07 log CFU/mL (Hemmatian et al., 2015). Although the Poosti cheese is matured in a coating which is prone to contamination, the moisture content in this cheese at 30 days of maturation classifies it as low moisture (Brasil, 1996; Hemmatian et al., 2015), unlike the formulated Labneh, which has a very high humidity content and, consequently, more prone to bacterial growth. Allied to this, the manufacture of Labneh involves dairy culture for the production of yogurt, which leads to an increase in the bacterial population in this product.

The results for molds and yeasts (Figure 3-II) varied from 4.94 to 3.48 log CFU/g in formulation L1, with a significant decrease ($p < 0.05$) between sampling times. In the L2 formulation, the values were from 7.88 to 5.04 log CFU/g, significantly higher ($p < 0.05$) than the formulation L1. In a study with freshly produced Labneh buffalo cheese, the average value for molds and yeasts was 7.53 log CFU/g (Salem et al., 2013), higher than that observed in formulation L. In this Labneh cheese, there was no growth of molds and yeasts in day 1 and 15 of storage, probably because the formulation contained leaves of a plant with antifungal and antimicrobial properties (Salem et al., 2013). The results found in three different commercial brands of buffalo mozzarella cheese were lower than that found in the present study and ranged from less than 0.48 to 0.80 log CFC/g (Facchin et al., 2014). In a study carried out with bovine milk cheese containing very high humidity, the counts were 6.35 and 7.21 log CFU/g, at 15 and 30 days of maturation (Vasek et al., 2013), comparable to the formulation L2. Yeasts are able to grow in milk and dairy products, due to their ability to assimilate and ferment lactose, assimilate citric and lactic acids, produce lipases and extracellular proteases (Facchin et al., 2014).

For psychrotrophics (Figure 3-III), the minimum and maximum results were, respectively, 3.92 and 5.07 log CFU/g for formulation L1 and 3.81 and 5.91 log CFU/g for formulation L2, without significant variations ($p < 0.05$) between formulations or sampling times. The presence of high psychrotrophic counts was not associated with a decrease in protein content (Figure 2-II), suggesting that in this microbial population there was no predominance of proteolytic psychrotrophics (Forsythe, 2013). In sheep milk Poosti cheese, the psychrotrophic count was 7.27 log CFU/g at 30 days (Hemmatian et al., 2015), higher than those found in the entire storage period for Labneh's formulations. Psychrotrophs have the ability to multiply in refrigeration temperatures and to produce enzymes, such as proteases and lipases, which can compromise the quality of derivatives (Forsythe, 2013). The presence of *Pseudomonas fluorescens*, a proteolytic psychrotrophic bacterium, in milk intended for Labneh caused fragility of the curd and high syneresis in the dough, as well as loss of yield in the manufacture (Ferreira et al., 2012), emphasizing the importance of quantifying the psychrotrophic group in this type of product. It should be noted that the lactic acid bacteria added in the processing of Labneh, for the production of yogurt, grow at refrigeration temperatures and can be quantified in the psychrotrophic (Forsythe, 2013), therefore the counts observed in Labneh's formulations may be related to these lactic bacteria.

The verification of total and thermotolerant coliform groups and *Staphylococcus aureus* in refrigerated Labneh sheep cheese is shown in Table 2. Among the groups presented, Brazilian legislation establishes parameters for thermotolerant coliforms and *Staphylococcus aureus* for this type of cheese (Brasil, 2001), but it is important to note that the group of total coliforms is an indicator of hygienic-sanitary quality of the raw material used to obtain the product (Balthazar et al., 2019a; Forsythe, 2013). The presence of total and thermotolerant coliforms was observed up to 60 days of storage in formulation L1 and only on the first day in L2. At the 60-day sampling time of formulation L1, the value found for thermotolerant coliforms was above 3.04 log MPN/g, exceeding the legal limit, which is 2.69 log MPN/g. In Labneh buffalo cheese, the presence of total coliforms was not detected at times 1 and 15 days (Salem et al., 2013), results lower than those found in this study. The quantification of total coliforms in different sheep cheeses ranged from 0.95 to 2.04 log MPN/g and for thermotolerants between 0.54 and 2.04 log MPN/g (Nespolo & Brandelli, 2012). In sheep Ricotta cheese, the count of total coliforms at eleven days of storage was 3.11 log CFU/g (Mancuso et al., 2014), comparable to the times of formulations of the sheep Labneh with the highest counts, and the counts in bovine milk curd, at times 1, 15 and 30 days, were 5.63, 4.42 and 3.71 log MPN/g (Vasek et al., 2013), higher than those observed in this study for both formulations.

Staphylococcus aureus counts showed maximum values of 1.37 log CFU/g in formulation L1 and 2.40 log CFU/g in formulation LU, both after 30 days of cold storage (Table 2), all values below the maximum allowed in the legislation. In other sheep cheeses produced in Southern Brazil, *S. aureus* counts were

Table 2. Evaluation of total, thermotolerant coliforms and *Staphylococcus aureus* in the formulations of Labneh cheese during cold storage.

Sample (Period – days)	Total coliforms (log MPN/g)	Thermotolerant coliforms (log MPN/g)	*Staphylococcus aureus* (log CFU/g)
L1 (1)	0.94 ± 0.35^{de}	1.25 ± 0.69^{b}	n.d.*
L1 (30)	1.56 ± 0.27^{cd}	0.80 ± 0.22^{bc}	1.37 ± 0.56^{a}
L1 (60)	$\geq 3.04^{a}$	$\geq 3.04^{a}$	0.67 ± 0.44^{a}
L1 (90)	$\leq 0.48^{e}$	$\leq 0.48^{c}$	0.65 ± 0.43^{a}
L1 (120)	$\leq 0.48^{e}$	$\leq 0.48^{c}$	n.d.*
L1 (150)	$\leq 0.48^{e}$	$\leq 0.48^{c}$	1.33 ± 0.44^{a}
L2 (1)	2.01 ± 0.69^{bc}	1.25 ± 0.08^{b}	n.d.*
L2 (30)	$\leq 0.48^{e}$	$\leq 0.48^{c}$	2.40 ± 0.27^{b}
L2 (60)	$\leq 0.48^{e}$	$\leq 0.48^{c}$	1.07 ± 0.29^{a}
L2 (90)	$\leq 0.48^{e}$	$\leq 0.48^{c}$	0.98 ± 0.21^{a}
L2 (120)	$\leq 0.48^{e}$	$\leq 0.48^{c}$	1.97 ± 0.64^{ab}
L2 (150)	$\leq 0.48^{e}$	$\leq 0.48^{c}$	n.d.*
Maximum limit**	-	2.69	2.69

L1 = formulation with pressing time of 4 hours; L2 = formulation with pressing time of 3 hours; MPN = most probable number. Mean values ± standard deviation of the mean (n = 3). Same letters in the same column do not differ statistically ($p < 0.05$). *n.d. corresponds to not detected in the initial dilution tested (10-1); **Values related to very high humidity cheeses, above 55% (Brasil, 2001).

between 1.95 and 4.45 log CFU/g (Nespolo & Brandelli, 2012). In three commercial brands of buffalo mozzarella cheese, the values found for *S. aureus* ranged from 0 to 4.98 log CFU/g (Facchin et al., 2014). The evaluation of *Salmonella* sp. and *Listeria monocytogenes* indicated the absence of these microorganisms in in both formulations. This result is in accordance with the parameters defined in the current legislation (Brasil, 2001).

Microbiological evaluation indicated only one result above the limit established for thermotolerant coliforms in the formulation L1 sampled after 60 days of storage, however this group was no longer quantified in the following samplings, with results at the minimum detection limit of the method. This demonstrates that the Labneh cheese from sheep milk can be stored under refrigeration for 150 days of shelf life, regardless of whether it is subjected to 3 or 4 hours of pressing prior to packaging. The satisfactory results in the microbiological and physical-chemical evaluations demonstrated that the production method was efficient to obtain a stable product and that it can be commercialized in the chosen presentation and packaging.

More tests will be needed to assess the acceptance of Labneh sheep's milk cheese in order to verify the market potential of this product. Sensory methodologies based on consumer´s perception have gained importance for evaluate dairy products (Judacewski et al., 2019; Rodrigues et al., 2020; Soares et al., 2019), as the free word association method that allows us to understand the sensory attributes that lead to frequent and occasional consumption and define strategies to stimulate consumption by those who do not buy the product (Judacewski et al., 2019). The sorting task method helps to group similar samples and the methodologies that use consumer description and preferred attribute elicitation make it possible to assess consumer's perception and characterize products based on the evaluation of their sensory attributes (Rodrigues et al., 2020; Soares et al., 2019). These sensory methodologies can be used to evaluate and improve a novel dairy like Labneh sheep's milk cheese before commercialization in the Brazilian market.

4 Conclusion

In these study two novel formulations for Labneh cheese were successfully developed using sheep's milk. Both formulations showed microbiological results adequate to the legislation even after 150 days of storage under refrigeration. The main difference between formulations was the pressing time of three or four hours prior to packaging and the results showed no need for this additional time. In addition, the developed sheep milk Labneh cheese was classified as a semi-fat cheese with very high humidity, presenting the desired spreadability characteristic.

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