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Evaluation of sanitary quality of goat milk in dairy industries from the Cariri region, state of Paraíba

Avaliação da qualidade sanitária do leite de cabra em indústrias leiteiras da região do Cariri, estado da Paraíba

Evaluación de calidad sanitária de leche de cabra em industrias lácteas de la región del Cariri, estado de Paraíba

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Abstract

The sanitary evaluation of equipment and hands is fundamental to investigate the presence of pathogens in the dairy industry. Then, this study aims to evaluate the sanitization of equipment, workers' hands, raw and pasteurized milk in goat milk dairies in the Cariri region, state of Paraíba. Collected 32 samples of four dairies represented by letters A, B, C, and D. The followings contents were analyzed: mesophiles, total and thermotolerant coliforms, *Escherichia coli*, *Staphylococcus aureus*, *Samonella* spp. and *Listeria monocytogenes* in the reception tank, pasteurization tank, packing machine, package, wall, workers' hand, and each dairy's raw and pasteurized milk. After isolation, 84 colonies were confirmed by MALDI TOF. The indicator microorganisms presented variations for the workers' hands, while A and B stayed within the patterns. For the equipment, only dairy B was within limits. They were out of the standard for mesophiles, total coliforms, and thermotolerant regarding raw and pasteurized milk. The microorganisms, the

Enterobacteriaceae family presented a higher frequency, with 77.38%, and within this family, *Escherichia coli*, *Klebsiella* spp., and *Enterobacter* spp. were the most prevalent. Gram-positive corresponded to 22.62%, *Bacillus* spp., *Staphylococcus* spp., *Enterococcus* spp., and *Macrococcus caseolyticus*. *Listeria monocytogenes* and *Salmonella* spp. were not isolated. These demonstrate failures in goat milk processing with pathogenic bacteria in several dairy plants, indicating the need to adjust the product's quality control.
Keywords: Dairy; Sanitization; Microorganisms.

Resumo
A avaliação sanitaria de equipamentos e mãos é fundamental para investigar a presença de patógenos na indústria de laticínios. Assim, este estudo teve como objetivo avaliar a higienização de equipamentos, mãos de trabalhadores, leite cru e pasteurizado em laticínios de leite de cabra na região do Cariri, estado da Paraíba. Coletaram-se 32 amostras de quatro laticínios representados pelas letras A, B, C e D. Os seguintes conteúdos foram analisados: mesófilos, coliformes totais e termotolerantes, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp. e *Listeria monocytogenes* no tanque de recepção, tanque de pasteurização, máquina de embalagem, embalagens, paredes, mãos dos trabalhadores e leite cru e leite pasteurizado de cada laticínio. Após o isolamento, 84 colônias foram confirmadas por MALDI TOF. Os microrganismos indicadores apresentaram variações para as mãos dos trabalhadores, enquanto A e B permaneceram dentro dos padrões. Para o equipamento, apenas o leite B estava dentro dos limites. Eles estavam for a do padrão para mesófilos, coliformes totais e termotolerantes em relação ao leite cru e pasteurizado. Os microrganismos,da família Enterobacteriaceae, apresentaram maior frequência, com 77,38%, e dentro desta família, *Escherichia coli*, *Klebisiella* spp. e *Enterobacter* spp. foram os mais prevalentes. Gram-positivos corresponderam a 22,62%, *Bacillus* spp., *Staphylococcus* spp., *Enterococcus* spp., *Macrococcus caseolyticus*, *Listeria monocytogenes* e *Salmonella* spp. não foram isolados. Foram demonstradas falhas no processamento do leite de cabra com bactérias patogênicas em várias fábricas de laticínios, indicando a necessidade de ajustar o controle de qualidade do produto.
Palavras-chave: Laticínio; Higienização; Microrganismos.

Resumen
La evaluación sanitaria de equipos y manos es fundamental para investigar la presencia de patógenos en la industria láctea. Luego, este studio tiene como objetivo evaluar la higienización de equipos, manos de trabajadores, leche cruda y pasteurizada en lecherías de leche de cabra en la region de Cariri, estado de Paraíba. Se recolectaron 32 muestras de cuatro lecherías representadas por las letras A, B, C y D. Se analizaron los siguientes contenidos: mesófilos, coliforms totals y termotolerantes, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp. y *Listeria monocytogenes* en el tanque de recepción, tanque de pasteurización, empaquetadora, empaque, pared, manos de los trabajadores y la leche cruda y pasteurizada de cada lechería. Después del aislamiento, se confirmaron 84 colonias mediante MALDI TOF. Los microorganismos indicadores presentaron variaciones para las manos de los trabajadores mientras que A yB se mantuvieron dentro de los patrones. Para el equipo, solo la lechería B estaba dentro de los límites. Estaban fuera del estándar para mesófilos, coliformes totales y termotolerates con respect a la leche cruda y pasteurizada. Los microorganismos, la familia Enterobacteriaceae presentaron una mayor frecuencia, con 77,38%, y dentro de esta familia, *Escherichia coli*, *Klebisiella* spp. y *Enterobacter* spp. fueron los más frecuentes. Los grampositivos correspondieron al 22,62%, *Bacillus* spp., *Staphylococcus* spp., *Enterococcus* spp. y *Macrococcus caseolyticus*, *Listeria monocytogenes* y *Salmonella* spp. no estaban aislados. Estos demuestran fallas en el procesamiento de la leche de cabra con bacterias patógenas env arias plantas lecheras, lo que indica la necesidad de ajustar el control de calidad del producto.
Palabras clave: Lácteos; Higienización; Microorganismos.

1. Introduction

Cariri region in Paraíba, Brazilian Northeast, in the late 1990s was one of the poorest regions in Brazil. The area was one of the most significant socioeconomic problems in the country; a situation worsened during prolonged droughts due to precarious productive organization. The maintenance of the same scenario in the early 2000s clarified the need for an intervention to promote deep transformations in the region's socioeconomic, environmental, and productive environment. It was then decided to implement a dairy goat program (Rodrigues; Quintans, 2015), which turned the state of Paraíba into the biggest goat milk producer in the country, producing more than 5.5 million liters of milk per year, according to the Brazilian Institute of Geography and Statistics (IBGE) (2018).

The goat milk is rich in vitamins and minerals, appropriate to the elderly, sick, and children's diet since it has digestion and absorption twice as fast as cow's milk (Mendes; Silva; Abrantes, 2009; Cenaci *et al.*, 2011). It is easily digested and has a high nutritional value with many probiotics, including lactic acid bacteria (Garcia *et al.*, 2014). However, milk must

pass through reasonable quality control to be competitive in the market, establishing a production system that prioritizes competitiveness and security for consumers (Rosa *et al.,* 2017).

Due to its high nutritional value, goat milk is ideal for microorganisms' growth and multiplication. Besides primary contamination during animal husbandry, there are critical points during the dairy production chain, such as processing, transportation, and final product storage (Weschenfelder *et al.,* 2016; Agrimonti *et al.,* 2017).

According to the Center for Disease Control and Prevention (CDC) (2013), the workers are likely transmitters of food diseases pathogens when failures and mistakes are made. Equipment and utensils have this risk when they are not correctly sanitized, producing microbial multiplication (Andrade, 2008). Thus, the failure in hygiene care during the production chain may result in milk with high microbial content, questionable quality, and outside the standards required by legislation, which increase the probability of risks to human health (Silva *et al.,* 2017). Therefore, it is essential to control and monitor the contamination, multiplication, and microbial survival in products, surfaces, equipment, utensils, and workers, contributing to the obtention of high-quality products (Andrade, 2008).

Then, this study aims to evaluate the presence of microorganisms in equipment, raw and pasteurized milk in goat dairies of the Cariri region in Paraíba.

2. Methodology

Four goat milk dairy industries from Cariri in Paraíba were selected, identified as A, B, C, and D. These dairy industries provide milk for the Food Acquisition Program (FAP). Samples were collected from each dairy's products, one from the cooling tank, one from the pasteurization tank, one from the packing machine, one from the packages, one from the worker's hand, and one from the wall. Two milk samples per dairy were selected to evaluate the quality, one from the raw milk, obtained from the cooling tank (from the aggregate), and the other from the milk after the pasteurization process. The collection was repeated four times, totalizing 32 samples.

The collection of material from utensils was made after the cleaning procedure. A sterile swab with a rod of 12 cm moistened in peptone water solution at 0.1% was rubbed for the samples of surfaces. The size of the surface evaluated with $100cm^2$ was delimited with a sterilized mold. The swab was applied with constant pressure with rotating movements, in an inclination of about 30° from left to right initially and then from right to left. The handled part of the swab was broken in the inner edge of the flask with 10 ml peptone water containing the dilution solution. After that, the plating of aliquots was conducted in the appropriate culture medium (Andrade, 2008).

A sterile swab with a 12cm rod moistened in a solution of peptone water at 0.1% was used for the worker's hands, rubbing the cotton three times towards each finger from the fist. After this, beginning from the fist, the swab was rubbed between the fingers, returning to the fist. The microorganisms collected were transferred to a pipe with 10 ml of the peptone water solution (Andrade, 2008). Then, dilutions were made to the adequate media for each microorganism.

For the standard counting of viable mesophilic microorganisms, decimal dilutions were prepared using peptone water at 0.1%. Then, 1 ml of each dilution of 10^0 to 10^3 was used for utensils, workers' hands, and pasteurized milk, and of 10^1 to 10^4 for raw milk, which was deposited in the bottom of sterilized Petri plates in duplicate, distributed in two series, and 15 to 17 ml of standard agar was added (Swanson *et al.* 1992). After homogenizing and solidifying agar at room temperature, the plates were incubated at 35°C per 48 hours to count the mesophilic microorganisms. According to the standard technique, the counts were performed with a colony counter, using plates with 25 to 250 CFU/mL (Colony Forming Units per milliliter). In the negative results for this interval, the obtained results were considered as estimated.

For enumeration of total coliforms and thermotolerant, 25ml of the sample was added in 225mL of buffered peptone water at 0.1%. The analysis was conducted with the multiple tube test (APHA, 2001). The sample was diluted, and the aliquots

were transferred to test tubes containing Lauryl Tryptose Broth and incubated at 37°C per 24-48h. To confirm the results, the test tubes that presented positive results were transferred to a test tube containing Brilliant Green Bile Lactose Broth 2% and EC broth, which have been incubated at 37 and 45°C per 24 and 48h, respectively. The samples' densities of total coliforms and thermotolerant were obtained in table Most Likely Number (MLN) (APHA, 2001).

The presence of *Escherichia coli* was confirmed by the inoculation of aliquots from the positive tubes for thermotolerant coliforms into plates containing eosin methylene blue agar (EMB). The typical colonies were transferred to tubes containing plate count agar (PCA), incubated at 37°C per 24 hours, and then submitted to phenotypical characterization through indole, citrate, and MR-VP tests (APHA, 2001).

For count of coagulase-positive staphylococcal, 25ml of the sample was added in 225 ml of peptone water at 0.1% (Acumedia) for milk, following APHA (2001). For the swabs of the utensils, an aliquot of 1 ml of peptone water was removed, and decimal dilutions were made. The decimal dilutions of the samples were inoculated in a Baird Parker agar, supplemented with com egg yolk and potassium tellurite, and incubated at 37°C per 48h. After incubation, a presumptive count of the colony-forming units (CFU) was conducted. The presumptive colonies were selected and transferred to a Brain Heart Infusion broth; the confirmation was provided by phenotypic tests of Gram coloring, catalase, and coagulase production.

For *Salmonella* spp. research, 25ml of the sample was added in 225 ml of peptone water at 0.1% (Acumedia). For the swabs of the utensils, an aliquot of 1 ml of peptone water was removed, and decimal dilutions were conducted. For selective enrichment, aliquots were transferred to test tubes containing Tetrathionate and Rappaport Vassiliadis broths, and the respective tubes were incubated at 37°C per 24h. Then, a selective medium, *Salmonella* differential agar, was used, incubated at 37°C per 24h. Colonies with typical characteristics of *Salmonella* spp. were submitted to phenotypic tests in TSI slant, Lysine Iron agar, Urea broth, indole, citrate, and MR-VP (APHA, 2001).

A total of 225mL of Listeria enrichment broth (LEB-Oxoid) was added in 25ml of each sample. For the swabs of the utensils, 25 ml of peptone water was removed and placed in the Listeria enrichment broth (LEB- Oxoid). Then, the Fraser broth was used for the selective enrichment and incubated at 37°C per 48h. Posteriorly, the inoculation was conducted in Oxford agar and set at 37°C per 48h. Typical colonies of *Listeria* were submitted to phenotypical identification based on Gram coloring, catalase production, motility, and carbohydrate fermentation.

A total of 84 isolated colonies were submitted to identification using matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS), following the protocol described by Barcelos *et al.* (2019). The research methodology and organization carried out in accordance with Pereira, et al., (2018).

3. Results and Discussion

The microbiological results are presented in Table 1. In total, 84 isolates were identified. *Escherichia coli*, *Klebsiella* spp., and *Enterobacter* spp. were the most frequent microorganisms. *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Serratia marcescens*, and *Providencia* had a lower frequence. Among the isolates of *Klebsiella*, the identified species were *K. oxytoca* and *K. Pneumoniae.* The isolates of *Enterobacter* spp. were *E. Asburiae*, *E. cloacae*, and *E. Kobei*. Only 11 samples were Gram-positive bacteria, among them *Staphylococcus* spp., *Bacillus* spp., *Enterococcus* spp., and *Macrococcus caseolyticus.*

Table 1 - Microorganisms identified by MALDI-TOF MS and their occurrence in dairy products' samples.

Microorganisms	**N. of isolates**	**Frequency(%)**
Escherichia coli	22	26.19
Klebsiella (pneumonaie e *oxytoca)*	19	22.61
Enterobacter (*asburiae, cloacae* e *kobei)*	15	17.85
Pseudomonas aeruginosa	8	9.52
Enterococcus (faecium, faecalis)	6	7.14
Proteus	6	7.14
Bacillus (*subtilis* e *megaterium*)	2	2.38
Serratia (marcescens)	2	238
Staphylococcus (aureus e *epidermidis)*	2	2.38
Macrococcus caseolyticus	1	1.19
Providencia	1	1.19
Total	84	100

Fonte: Autores.

The results of indicators microorganisms are in Table 2. According to Andrade (2008), there are no patterns or specifications for the microbial count in workers' hands; it is only determined scales used to define the hygienic-sanitary conditions for mesophiles and coliforms between 10^3 and 10^4 CFU /hand. According to the data found in this study, the mesophiles in workers' hands in all the dairies studied are within the patterns. Furlan and Valejo (2017) found unsatisfactory results for mesophiles in 80% of the hands of workers who collected milk in rural properties in Paraná. This inadequate manipulation and carelessness concerning hygiene standards contribute to higher contamination by pathogenic microorganisms (Mello *et al.*, 2010).

As occurs with workers' hands' hygiene, Brazil does not have legislation with microbiological standards for equipment and utensils. Many researchers follow the recommendations of the World Health Organization (WHO) and Pan American Health Organization (PAHO) that accept counts of 50 CFU cm^2 for aerobic mesophiles and 76.7 for total coliforms (Aandrade, 2008). The utensils evaluated regarding mesophiles, the pasteurization tank, the packaging machine, and the reception tank presented counts out of standards for mesophiles in dairies A, C, and D. Dairy B every had all evaluated aspects within the counts established by the international legislation.

The mesophiles patterns for raw goat milk are regulated in Brazil by IN n. October 37, 2000 that established a maximum value of $5x10^5$ CFU/mL (BRASIL, 2000). In this study, the raw milk from Cariri, Paraíba, presented high mesophilic counts in dairies A, B, and C. Only dairy D was within the patterns, but with values close to the limits established by legislation. Such findings corroborate the values presented by Coelho *et al*. (2018), who found mesophiles values from $5,3x10^2$ to $5,3x10^5$. The same authors state that such values are due to the lack of hygiene during milking and the delay in the cooling process. Padua *et al.* (2019) found an average of $7,6x10^3$ CFU/mL, a value within the standards.

The mesophiles count for pasteurized milk is within limits established, except for dairy C, which obtained values of $2,5x10^5$ CFU/ml. The group of mesophilic bacteria is constituted by *Enterobacteriaceae*, *Clostridium* spp., *Streptococcus* spp., *Corynebacterium* spp., etc. *Enterobacteriaceae* are the most significant and dangerous, causing intestinal and urinary infection, sepsis, and even the death of red blood cells due to lactic acid production (Furlan; Valejo, 2017).

The total coliforms and thermotolerant in workers' hands were within the patterns, according to Andrade (2008). The values of total coliforms varied from <0.3 to 2.3 MLN/mL and from < 0.3 to 1.5 MLN/mL for thermotolerant coliforms. Such

data corroborate those found by Candeira *et al.* (2020) and Figueiredo *et al*. (2016), who found satisfactory results for workers' hands in a dairy farm in the state of Pará. Concerning equipment and utensils, all dairies in this study are within the standards. Values varied from <0.3 to 24 for total coliforms and thermotolerant, corroborating Candeira *et al.* (2020), who found satisfactory results while evaluating a dairy farm's equipment.

The total coliforms are composed of bacteria from the Enterobacteriaceae family that can ferment lactose and produce gas when incubated at 35-37ºC per 48 hours (Mendes *et al.*, 2009). The thermotolerant coliforms are characterized by their capacity to ferment lactose with acid and gas production at the temperature of 45°C (Coelho *et al.*, 2018). These microorganisms constitute a subgroup of total coliforms, in which their presence indicates the probability of contamination with fecal material (Mendes *et al*., 2009). A study by Dutra *et al.* (2014) with raw goat milk at different storage temperatures found a variation from <3 to >1100 MLN/mL. Although a standard for coliforms in raw milk does not exist, according to Coelho *et al.* (2018), the presence of bacteria from the coliforms group in samples of raw goat milk may indicate milk contamination.

The results of total and thermotolerant coliforms of pasteurized milk varied from 2.1 to 240 MLN/mL and 2.1 to 460 MLN/mL, respectively. According to the legislation, the established limit is 2 MLN for total coliforms and 0 MLN/ml for thermotolerant coliforms, demonstrating that all evaluated dairies are outside the standards for total coliforms and thermotolerant (BRASIL, 2000).

Several studies found unsatisfactory sanitary quality while studying total coliforms and thermotolerant in pasteurized goat milk (Andrade *et al*., 2008; Maraschin *et al.*, 2004; Silva *et al*., 2017;). However, Santos *et al.* (2012) and Fonseca *et al.* (2006) did not found thermotolerant coliforms in pasteurized milk.

The coliforms are destroyed by pasteurization. Their presence in pasteurized milk indicates the need for more effective time and temperature control in the pasteurizer, better selection of raw milk suppliers, and sanitization of utensils with milk after pasteurization. This fact clarifies the need for revaluation of these steps to identify and diagnose all sources of contamination. (Silva *et al.*, 2008; Martins *et al.*, 2012).

The isolated colonies of utensils, raw and pasteurized milk analyzed in this study were submitted to identification by MALDI-TOF MS. In Table 3, it is observed that of 24 samples from equipment and workers' hands, 66.67% were contaminated. According to Andrade (2008), on the surfaces of utensils, the pathogens must be absent. The packages were one of the places with the highest presence of pathogenic microorganisms in all dairies. There is a direct relation between them because employees are responsible for handling the packaging, making them critical control points within the dairy. Dairy D was the most contaminated, with the presence of pathogenic microorganisms in all the evaluated places. Dairy C presented a lower frequency of contamination, with microorganisms on workers' hands, pasteurization tank, and packages.

Table 2 – Enumeration of total coliforms, thermotolerant and mesophiles in equipment, raw and pasteurized goat milk of the Cariri region in Paraíba from January to February 2019.

Microorganisms	Dairy	Workers' hand	Reception tank	Pasteurization tank	Packaging machine	Package	Wall	Raw Milk	Pasteurized milk
Mesophiles CFU/**cm²**	A	$7.4x10^2$	$1.7x10^2$	$5.5x10^2$	Negative	$3.7x10^2$	Negative	$>2.5 \times 10^4$	$9.0x10^3$
	B	$5.5x10^1$	$2.4x10^1$	$<2.5x10^1$	$<2.5x10^1$	Negative	Negative	$>2.5 \times 10^4$	$4.3x10^2$
	C	4.5×10^3	$>2.5x10^2$	$5.1x10^4$	Negative	$4.3x10^3$	$>2.5x10^2$	$>2.5 \times 10^4$	$>2.5 \times 10^3$
	D	$1.3x10^3$	$4.6x10^2$	$>2.5x10^2$	$<2.5x10^1$	$2.7x10^2$	$1.1x10^3$	$4.8x10^5$	$8.3x10^2$
Total Coliforms MLN/cm²	A	2.3	2.3	0.9	<0.3	0.9	<0.3	2.4×10^5	460
	B	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	$2.4x10^5$	>240
	C	1.5	<0.3	<0.3	<0.3	<0.3	<0.3	$2.4x10^5$	2.1
	D	<0.3	24	<0.3	<0.3	1.5	<0.3	$2.4x10^5$	110
Thermotolerant Coliforms MLN/cm²	A	0.4	<0.4	0.4	<0.3	0.9	<0.3	$2.4x10^5$	460
	B	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	$1.5x10^4$	110
	C	1.5	<0.3	<0.3	<0.3	<0.3	<0.3	$2.4x10^5$	2.1
	D	<0.3	24	<0.3	<0.3	4.3	<0.3	$2.4x10^5$	110

Fonte: Autores.

Table 3 - Bacterial species identified by MALDI TOF in equipment, raw and pasteurized goat milk of dairies in the Cariri region, Paraíba, from January to February 2019.

Site	Dairy industries			
	A	**B**	**C**	**D**
Workers' hand	*Klebsiella pneumoniae* *Bacillus megaterium*	*Enterobacter cloacae* *Staphylococcus epidermidis*	*Klebsiella pneumoniae* *Bacillus subtilis*	*Providencia*
Reception tank	*Proteus mirabilis*	*Klebsiella pneumoniae*	-	*Enterobacter cloacae* *Pseudomonas aeruginosa* *Enterococcus* spp.
Pasteurization tank	-	*Enterobacter cloacae*	*Pseudomonas aeruginosa*	*Klebsiella pneumoniae* *Proteus mirabilis* *Enterococcus* spp.
Packaging machine	*Pseudomonas aeruginosa*	-	-	*Enterobacter cloacae* *Proteus mirabilis* *Enterococcus* spp.
Packages	*Klebsiella pneumoniae*	*Enterobacter cloacae* *Serratia marcescens*	*Pseudomonas aeruginosa*	*Enterobacter cloacae* *Serratia marcescens* *Enterococcus* spp.
Wall	-	-	-	-
Raw milk	*Escherichia coli* *Enterobacter cloacae* *Klebsiella pneumoniae* *Proteus mirabilis* *Staphylkococcus aureus*	*Escherichia coli* *Klebsiella oxytoca* *Klebsiella pneumoniae* *Pseudomonas aeruginosa*	*Escherichia coli* *Klebsiella oxytoca* *Klebsiella pneumoniae* *Enterococcus* spp.	*Escherichia coli* *Enterobacter cloacae* *Enterobacter kobei* *Enterobacter asburie* *Enterococcus* spp.
Pasteurized milk	*Klebsiella pneumoniae* *Enterobacter kobei*	*Escherichia coli* *Klebsiella pneumoniae* *Proteus mirabilis* *Pseudomonas aeruginosa*	*Escherichia coli* *Enterococcus* spp.	*Escherichia coli* *Enterobacter cloacae*

Fonte: Autores.

Of the 84 isolates obtained in goat milk dairies of the Cariri region, 77.38% are from the *Enterobacteriaceae* family, with six different genera. *Escherichia coli*, *Klebsiella* spp., and *Enterobacter* spp. were the species with the highest isolation frequency, comprising 66.66% of the isolates. These microorganisms are originated from the gastrointestinal tract of humans and animals. They are considered good indicators of sanitary food conditions (Cruz *et al.*, 2019). They are also able to generate protein and lipid breakdown, contributing to economic losses and waste (Baylis *et al.*, 2011) due to enzyme production

In Europe, the *Enterobacteriaceae* Family has been used as an indicator of dairy quality and the sanitary conditions of dairy products and their processing environment (Hervet *et al.*, 2016). Then, it is used as a marker of contamination and sanitary conditions during the processing and post-processing because its presence can indicate enteric pathogens (Moraes *et al*., 2009; Okura; Marin, 2014). *Escherichia coli* was found only in raw and pasteurized goat milk, indicating failures in the dairies' quality control. The contamination mechanisms can be cross-contamination between raw and cooked food, utensils not disinfected, and unsanitized workers' hands. They are also considered indicators of fecal contamination (Silva Júnior, 2014).

Klebsiella spp. and *Enterobacter* spp. were found in several goat milk processing environments, including workers' hands, reception tank, pasteurization tank, package, raw, and pasteurized milk. This fact indicates gaps in the cleaning process that need to be re-evaluated to secure sanitary product quality. *Klebsiella* spp. causes mastitis and is commonly found in the environment, water, beds, and soils. The two most frequent species are *K. pneumoniae* and *K. oxytoca* (Podschum; Ullmann, 1998; Cerqueira *et al.*, 2011Santos *et al.*, 2019; Santos Júnior *et al.*, 2019;).

Enterobacter spp. is widespread, composing the human and animal gastrointestinal tract flora, and sometimes becomes an opportunistic pathogen (Mezzatesta; Gona; Stefani, 2012). Its clinical significance increased during the last years, and it is now recognized as a significant nosocomial pathogen, especially for intensive care patients (for example, causing sepsis). These microorganisms are widely spread in the environment occurring in soil and sewer (Denton, 2007; Wisplinghoff *et al.*, 2004).

Listeria monocytogenes and *Salmonella* spp. were not found in the samples studied. However, other studies demonstrate their presence in the dairy industry (Monte *et al.*, 2016; Zegarra *et al.*, 2009). These microorganisms are associated with disease outbreaks related to milk intake (Cruz *et al.*, 2019).

The other genera, identified as *Bacillus* spp., *Staphylococcus* spp., *Enterococcus* spp., and *Macrococcus*, are Gram-positive microorganisms. Many of these species are pathogens with the potential to form biofilms (Alonso & Kabuki, 2019; Wang *et al.*, 2019; Novoa *et al.*, 2018; Lira *et al.*, 2016). When adhered to utensils, their elimination becomes more complex, and they may function as sources of pathogenic microorganisms for processed products.

4. Conclusion

The presence of several pathogenic bacterial species in equipment and raw and pasteurized goat milk in dairies of the Cariri region in Paraíba reveal failures in the cleaning process. The re-evaluation of the sanitary practices and the quality control adopted in dairies for processed products is necessary to ensure the final product's sanitary quality, and more studies of this type can be carried out to see if there have been improvements.

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