

## Physico-chemical characteristics and microbial profile “*in natura*” of goat milk from the region of Jaguaratama, Ceará, Brazil

Características físico-químicas y perfil microbiano de la leche de cabra cruda de la región de Jaguaratama, Ceará, Brasil

Características físico-químicas e perfil microbiano do leite *in natura* de cabra da região de Jaguaratama, Ceará, Brasil

Received: 11/09/2023 | Revised: 11/21/2023 | Accepted: 11/22/2023 | Published: 11/24/2023

**Rejane Maria Maia Moises**

ORCID: <https://orcid.org/0000-0002-8451-6391>

State University of Ceará, Brazil

Institute of Education, Science, and Technology of Ceará, Brazil

E-mail: [rejanemaia@ifce.edu.br](mailto:rejanemaia@ifce.edu.br)

**John Kelvyn de Oliveira**

ORCID: <https://orcid.org/0009-0008-3425-2739>

Institute of Education, Science, and Technology of Ceará, Brazil

E-mail: [john.kelvyn.oliveira07@aluno.ifce.edu.br](mailto:john.kelvyn.oliveira07@aluno.ifce.edu.br)

**Cristiane Clemente de Mello Salgueiro**

ORCID: <https://orcid.org/0000-0003-0071-4903>

State University of Ceará, Brazil

E-mail: [crismelloacp@gmail.com](mailto:crismelloacp@gmail.com)

**Maria Silvaneide Pereira Leitão**

ORCID: <https://orcid.org/0009-0002-1906-0233>

Institute of Education, Science, and Technology of Ceará, Brazil

E-mail: [silvaneide.leitao08@aluno.ifce.edu.br](mailto:silvaneide.leitao08@aluno.ifce.edu.br)

**José Ferreira Nunes**

ORCID: <https://orcid.org/0000-0003-1189-0937>

State University of Ceará, Brazil

E-mail: [nunesuece@gmail.com](mailto:nunesuece@gmail.com)

### Abstract

Caprine farming has experienced remarkable growth in recent years, especially in the Northeast region of Brazil. In this area, historical and geoclimatic factors have played a crucial role in the success of caprine farming, making it a standout on the national stage. Goat's milk, with its richness in fat and nutrients, serves as an excellent raw material for the production of dairy derivatives. Therefore, the analysis its quality holds significant importance in ensuring the excellence of derived products. The objective of this research was to assess the microbiological and physicochemical quality “*in natura*” of goat milk from Jaguaratama, Ceará, Brazil. Ten raw goat milk samples were collected from various producers in the municipality of Jaguaratama-Ceará, Brazil. The microbiological and physicochemical parameters of these samples were analyzed in the Milk Technology Laboratory of the Federal Institute of Education, Science, and Technology of Ceará (IFCE), situated on the Limoeiro do Norte campus, CE. All samples in this study complied with the physicochemical parameters and thermotolerant Coliforms. However, a single sample exceeded the regulatory limits for total Coliforms, highlighting the need to enhance hygiene practices during milk production, transportation, and storage. It is crucial to emphasize the importance of adhering to good management and hygiene practices in milk production to ensure quality and safety. Maintaining high hygiene standards at all stages of the process is essential to meet regulations and meet the expectations of consumers seeking safe and nutritious dairy products.

**Keywords:** Caprine farming; Goat milk parameters; Microbiology.

### Resumo

A criação de caprinos tem experimentado um crescimento notável nos últimos anos, especialmente na região Nordeste do Brasil. Nesta área, fatores históricos e geoclimáticos desempenharam um papel crucial no sucesso da criação de caprinos, tornando-a um destaque no cenário nacional. O leite de cabra, com sua riqueza em gordura e nutrientes, serve como uma excelente matéria-prima para a produção de derivados lácteos. Portanto, a análise da sua qualidade tem uma importância significativa para garantir a excelência dos produtos derivados. O objetivo desta pesquisa foi avaliar a qualidade microbiológica e físico-química “*in natura*” do leite de cabra de Jaguaratama, Ceará, Brasil. Foram coletadas dez amostras de leite de cabra cru de diversos produtores no município de Jaguaratama-Ceará, Brasil. Os

parâmetros microbiológicos e físico-químicos dessas amostras foram analisados no Laboratório de Tecnologia do Leite do Instituto Federal de Educação, Ciência e Tecnologia do Ceará (IFCE), situado no campus de Limoeiro do Norte, CE. Todas as amostras deste estudo estavam em conformidade com os parâmetros físico-químicos e coliformes termotolerantes. No entanto, uma única amostra excedeu os limites regulatórios para coliformes totais, destacando a necessidade de aprimorar as práticas de higiene durante a produção, transporte e armazenamento do leite. É fundamental enfatizar a importância de aderir a boas práticas de gestão e higiene na produção de leite para garantir qualidade e segurança. Manter altos padrões de higiene em todas as etapas do processo é essencial para atender às regulamentações e às expectativas dos consumidores em busca de produtos lácteos seguros e nutritivos.

**Palavras-chave:** Criação de caprinos; Parâmetros do leite de cabra; Microbiologia.

### Resumen

La cría de caprinos ha experimentado un notable crecimiento en los últimos años, especialmente en la región noreste de Brasil. En esta área, los factores históricos y geoclimáticos han desempeñado un papel crucial en el éxito de la cría de caprinos, convirtiéndola en un destacado en el escenario nacional. La leche de cabra, con su riqueza en grasa y nutrientes, sirve como una excelente materia prima para la producción de derivados lácteos. Por lo tanto, el análisis de su calidad es de gran importancia para garantizar la excelencia de los productos derivados. El objetivo de esta investigación fue evaluar la calidad microbiológica y físicoquímica "in natura" de la leche de cabra de Jaguaretama, Ceará, Brasil. Se recogieron diez muestras de leche de cabra cruda de varios productores en el municipio de Jaguaretama-Ceará, Brasil. Los parámetros microbiológicos y físicoquímicos de estas muestras se analizaron en el Laboratorio de Tecnología de la Leche del Instituto Federal de Educación, Ciencia y Tecnología de Ceará (IFCE), situado en el campus de Limoeiro do Norte, CE. Todas las muestras de este estudio cumplieron con los parámetros físicoquímicos y coliformes termotolerantes. Sin embargo, una sola muestra superó los límites reglamentarios de coliformes totales, resaltando la necesidad de mejorar las prácticas de higiene durante la producción, transporte y almacenamiento de la leche. Es fundamental enfatizar la importancia de adherirse a buenas prácticas de gestión e higiene en la producción de leche para garantizar la calidad y la seguridad. Mantener altos estándares de higiene en todas las etapas del proceso es esencial para cumplir con las regulaciones y satisfacer las expectativas de los consumidores que buscan productos lácteos seguros y nutritivos.

**Palabras clave:** Cría de caprinos; Parámetros de leche de cabra; Microbiología.

## 1. Introduction

Caprine farming plays a significant role in the socio-economic context, serving as a source of income and food, including meat and milk. This activity is essential for the sustainability of small-scale producers in developing countries, such as Brazil (Felisberto et al., 2022). Brazil is considered the largest producer of goat milk in the Americas, with a production of 26 million liters per year, as reported by the Brazilian Institute of Geography and Statistics (IBGE) in 2019. The Northeast and Southeast regions are the primary contributors to goat milk production, accounting for 70% and 24% of the national production, respectively. This activity has an estimated production value of R\$57 million annually and directly involves 14,846 properties, as per IBGE data in 2019.

Due to the historical characteristics of the region, specific climate, and biome, goat farming has emerged as an economically significant activity. The Northeast region alone contributes an impressive 70% of the entire national goat milk production, emphasizing the importance of this sector in the region. It is noteworthy that despite a decline in production, partly attributed to producers withdrawing due to inadequate government incentives, the Northeast region continues to play a vital role in this sector, especially in recent years when it reached its highest production. This underscores the persistence and ongoing significance of caprine farming in the Northeast region of Brazil (Gonçalves et al., 2019).

While dairy goat farming is expanding in various regions of Brazil, several challenges are impacting the sector. Issues such as production seasonality, the growth of the goat herd, insufficient technological investment, and inadequate animal management have become hurdles in the production system. These problems result in an irregular milk supply, leading to dissatisfaction among both the industry and consumers. Availability and prices of goat products often fall short of expectations, causing market frustration (Pinto Júnior et al., 2012). Its growth is driven by increased demand both domestically and internationally. This is the result of collaborative efforts by research institutions, governments, and breeders' associations aimed at improving goat milk production and promoting the dairy industry, focusing on quality and health benefits. These

partnerships boost the interest in nutritious and functional foods with health advantages (Oliveira, 2023).

Goat milk differs from cow's milk in terms of allergenic potential due to variations in amino acid and protein structures. These differences make goat milk consumption particularly recommended for children and the elderly, as it is less likely to trigger allergies compared to cow's milk (Ramos Neto et al., 2021).

One of the most significant milestones in improving the quality of milk produced in Brazil was the implementation of specific regulations. Currently, Normative Instruction No. 62 of 2011 - IN62/2011, issued by the Ministry of Agriculture, Livestock, and Supply (MAPA), which amends the guidelines of IN51/2002, establishes stringent standards for the handling of raw milk. According to this regulation, milk must be kept refrigerated at a temperature of 4°C and stored on the rural property for a maximum of 48 hours. This refrigeration practice aims to control the proliferation of mesophilic aerobic bacteria, whose count reflects the hygiene conditions up to the milking moment, serving as an indicator of the effectiveness of the milk refrigeration system (Izidoro et al., 2013). This regulation plays a crucial role in ensuring the quality and safety of milk produced in the country.

While these measures are important, their isolated application is not sufficient to guarantee the quality of milk. It is essential to adopt hygienic practices throughout all stages of production to ensure that the industry receives bulk milk with a low total bacterial count (TBC). Failure to meet these criteria leads to irregularities in the microbiological and physicochemical quality of raw milk, and this problem still persists in various regions of Brazil (Alves et al., 2023). Despite its high perishability, milk exhibits physicochemical and biological characteristics that are susceptible to alterations, often caused by the action of microorganisms and handling.

Therefore, it is crucial to assess the presence of undesirable microorganisms in milk and its derivatives as they pose a threat to public health safety and are a critical factor in food quality. This is due to the various changes in the taste, aroma, and appearance of products caused by the unwanted proliferation of microorganisms (Lima et al., 2021; Alves et al., 2023).

In addition to the factors mentioned, the physicochemical quality of *in natura* milk plays a fundamental role in ensuring its consumption by the population and its use as a raw material in the production of dairy derivatives (Pequeno, 2018). However, in terms of compositional factors, hygienic and sanitary conditions during milking and the storage of goat milk in small properties in semi-arid regions often lack effectiveness. This can lead to a deterioration in the quality of the raw material and its derivatives, resulting in financial losses, including possible product rejection (Coelho et al., 2018).

Based on the above, the analysis of the physicochemical characteristics and microbial profile of goat milk plays a crucial role. This is essential to ensure that the raw material meets the appropriate parameters for industrial processing, enabling the implementation of programs that optimize the quality of milk and its derivatives. This not only leads to increased productivity but also provides nutritionally suitable food for consumers (Lima et al., 2021).

The objective of this research was to assess the microbiological and physicochemical quality “*in natura*” of goat milk from Jaguaretama, Ceará, Brazil.

## 2. Methodology

The research in question is of a qualitative-quantitative nature since it explored the relationships between the tested variables, as well as the results obtained from the sample analysis, allowing for their characterization. Additionally, observations during the analysis led to conclusions supported by the experimental data from the analyzed times, as described by Koche (2011).

### 2.1 Animals and Goat Milk Acquisition

The goat herd was composed of various species: Anglo, Brown Alpine, Sanen Toggenburg, American Alpine, and

British, with an average age ranging from 2.5 years. The animals were raised in a semi-intensive system, receiving a diet consisting of concentrated feed made from corn bran, wheat bran, silage, cottonseed cake, and soybean meal, while elephant grass and cactus were used as sources of roughage.

Goat milk was obtained from 10 producers in different districts, namely Açude do Pereiro, Jordão, Mundo Novo, Capina Alegre, and Capina Boqueirão, located in the municipality of Jaguaratama, adapting to the availability of the raw material. The milk samples *in natura* (n = 10) were collected directly from 3 animals ( $\pm 1000$  mL) on each property, identified, and properly transported in thermal boxes to the milk technology laboratory at the Federal Institute of Education, Science, and Technology of Ceará (IFCE), Campus Limoeiro do Norte, CE.

The characterization of goat milk followed the criteria and analysis methods described in the technical regulations for the production, identity, and quality of goat milk (Brazil, 2000), which establish minimum quality requirements for milk intended for human consumption. This includes sensory characteristics, physicochemical attributes, macroscopic and microscopic criteria, microbiological aspects, and tolerance levels.

## 2.2 Characterization of Goat Milk

All analyses were conducted in triplicate, following the official methodologies recommended by IAL (2008) and AOAC (2005), in accordance with the criteria described in the technical regulations for the production, identity, and quality of goat milk (Brazil, 2000), which establish minimum quality requirements for milk intended for human consumption.

- pH, using a pH meter model (Jenway - 3510 pH meter);
- Titratable Acidity, expressed in mg of lactic acid per gram ( $g^{-1}$ );
- Fat content by the Gerber method;
- Total Solids (TS) ( $g/100 g$ ) - calculated by the difference from moisture ( $TS = 100 - \text{Moisture}$ );
- Fat in the dry extract (FDE) ( $g/100g$ ) - calculated by dividing the fat content by the total solids, multiplied by 100.
- Protein ( $g/100 g$ ) - Kjeldahl method, using the correction factor of 6.38;
- Ash ( $g/100g$ ) - determined by the weight loss of the material incinerated in a muffle furnace at  $550^{\circ}C$ .

To perform cryoscopy, test tubes containing 2.5 mL of each sample from each producer were used, employing a benchtop digital electronic cryoscope ITR-MK 540 FLEX II. This device displayed the results directly on its screen, allowing for the analysis of the possible presence of water. Each sample was analyzed in duplicate, following the manufacturer's equipment instructions. Initially, the non-refrigerated milk sample was pipetted into the equipment's container, and then the device's head was activated to secure the glass containing the sample. When the test was completed, the device emitted an audible signal to indicate the end of the analysis, and the result obtained remained available on the device's display until a new analysis was performed.

## 2.3 Assessment of Microbiological Parameters in Goat Milk

In the microbiological quality control of raw goat milk, tests for mesophilic and psychrotrophic aerobic bacteria were conducted, employing official methodologies described in Normative Instruction No. 62/2003 (Brazil, 2003).

The milk samples were placed in sterilized containers and transported under refrigeration to the laboratory, where they were diluted up to  $10^{-3}$  in a 0.85% saline solution. Aliquots of 1 mL from each dilution were used for the determination of total coliforms ( $35^{\circ}C$ ) in Brilliant Green Bile Broth (BVB), incubated at  $35^{\circ}C$  for 48 hours in an oven. The confirmation of thermotolerant coliforms ( $45^{\circ}C$ ) was conducted in EC broth, incubated at  $45^{\circ}C$  for 48 hours in a water bath. Positive results were indicated by the presence of gas formation, as per Silva et al. (1997).

## 2.4 Statistical Analysis

The study was conducted using a factorial design and in triplicate. The statistical analysis of the results obtained from the descriptive test was conducted using analysis of variance (ANOVA) with Statistic 7.0 software (STATSOFT, 2007). To compare means, the Tukey test ( $p < 0.05$ ) was employed to detect significant differences among the average values.

## 3. Results and Discussion

### 3.1 Physicochemical Analysis of Goat Milk “*in natura*”

The goat milk samples, for the most part, demonstrated satisfactory quality with respect to their physicochemical composition and are deemed acceptable for the production of their derivatives. This is because all the parameters of the physicochemical composition analyzed fall within the requirements for goat milk in Brazil, as illustrated in Table 1.

**Table 1** - Mean values (mean  $\pm$  SD) of the goat milk “*in natura*” analyses.

ANALYSES	OBTAINED VALUES
pH	6.64 $\pm$ 0.00
ACIDITY (lactic acid/100 mL)	0.19 $\pm$ 0.00
CRYOSCOPY ( $^{\circ}$ H)	- 0.534 $\pm$ 0.0
DENSITY (15/15 $^{\circ}$ C, g/mL)	1.032 $\pm$ 0.42
FAT (%)	3.73 $\pm$ 0.07
PROTEIN (%)	3.10 $\pm$ 0.04
TTS (Total Dry Solids) (%)	13.00 $\pm$ 0.07
DFS (Defatted Dry Solids) (%)	9.00 $\pm$ 0.01
ASH (g/100g)	0.80 $\pm$ 0.05

Fonte: Autores.

The analysis of goat milk composition is of fundamental importance in the dairy industry and the production of dairy products. Each of the parameters presented plays a critical role in evaluating the quality and composition of milk, ensuring the consistency and safety of the final dairy products.

The assessment of goat milk *in natura* revealed the values were within the standards established by IN 37 (Brazil, 2000), which defines the identity and quality standards for goat milk. The obtained results were as follows: pH of 6.64, acidity of 0.19 g lactic acid/100 mL, cryoscopy of -0.534  $^{\circ}$ H, density of 1.032 g/mL, fat content of 3.73%, protein content of 3.10%, total solids of 13.00%, defatted dry solids of 9.00%, and ash content of 0.80 g/100g (Table 1).

Although not regulated by specific legislation, pH is a relevant piece of information for quality control. The pH value of 6.64 in raw goat milk was consistent with the literature and remained appropriate, suggesting the maintenance of product sanitary quality. pH plays a critical role in milk coagulation during dairy product production.

When compared to previous studies, the pH values obtained in this work were in agreement with quality standards. Mendes (2009) reported pH values ranging from 6.68 to 6.73 in goat milk produced in the semi-arid region of Rio Grande do Norte, and Park et al. (2007) described pH values ranging from 6.50 to 6.80 for goat and sheep milk.

The acidity of goat milk *in natura*, expressed in lactic acid, was 0.19 g/100 mL, within the range established by regulations. The cryoscopic point, -0.534  $^{\circ}$ H, was slightly below the range recommended by IN 37 (Brazil, 2000), which is -0.550 to -0.585  $^{\circ}$ H. However, the density of raw milk (1.032 g/L) was within the guidelines of IN 37, which allow variations

from 1.0280 to 1.0340 g/L. Determining density is crucial in detecting adulteration, as the addition of water reduces density, while the removal of fat increases it.

Regarding the fat content, raw goat milk presented 3.73%, in accordance with the literature, which records variations from 3.25% to 4.38% in Brazil (DUTRA, 2014). The fat in goat milk contains aliphatic lactones or their hydroxyacid precursors, which are associated with the development of flavors in heated and stored dairy products.

Interest in milk composition is undeniable, considering its nature as a dynamic fluid and the benefits it provides to human and animal health, especially regarding its impact on caprine microbiota. In this context, attention is directed towards the parameters that contribute to preserving milk, allowing it to maintain its quality for an extended period.

An outstanding example of one of these parameters is the protein content in goat milk. Protein plays a crucial role due to the availability of low molecular weight proteins and peptides that have promising nutraceutical and therapeutic applications. As observed by Verma et al. (2020) in their study, the identified proteins exhibit relevant physicochemical properties such as molecular weights, isoelectric points (pI), and sequences, paving the way for future bioassays to validate the activity of these proteins and peptides for application in human health promotion.

In the context of this study, the protein content of raw goat milk was evaluated, registering a content of 3.10%. This analysis provides a valuable contribution to understanding the composition of goat milk, especially concerning its nutritional quality and potential application in the food and health industry. The quantification of protein is of great importance as it influences the functionality of milk and its potential in the production of dairy products and nutritional supplements.

The values for total solids and defatted dry solids in goat milk *in natura* were 13.00% and 9.00%, respectively. The ash content was 0.80 g/100g, indicating the presence of minerals in the milk. The counts of the main groups of microorganisms identified in transition milk, in its raw form, are detailed in Table 2.

**Table 2** - Microbiological analysis of whole goat milk samples (Presumptive test for Total Coliforms and Thermotolerant Coliforms (NMP/g)).

<b>Determinations</b>	<b>L1</b>	<b>L2</b>	<b>L3</b>	<b>L4</b>	<b>L5</b>	<b>L6</b>	<b>L7</b>	<b>L8</b>	<b>L9</b>	<b>L10</b>
<b>Total Coliforms (35 °C) NMP/mL</b>	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	460 NMP/mL	<3.0	<3.0	<3.0
<b>Thermotolerant Coliforms (45 °C) NMP/mL</b>	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Caption: L - Goat Milk *in natura*. Fonte: Autores.

As shown in Table 2, the analysis of the microbiological quality of the milk revealed that 90% of the raw milk samples (L1; L2; L3; L4; L5; L6; L8; L9; L10) complied with regulatory standards, displaying an average of less than 3.0 colony-forming units per milliliter (CFU/mL). However, sample L7 exhibited a bacterial count, specifically total coliforms (35 °C), expressed in MPN/mL, that exceeded the established limit of  $3.0 \times 10^5$  CFU/mL. Regarding the microbiological analysis, it is noteworthy that all the samples analyzed met the desired standards established for thermotolerant coliforms (45 °C), remaining below the limit of 3.0.

The presence of elevated levels of total coliforms (35 °C) in a milk sample can be attributed to various factors, such as the milk's storage time on the dairy farm, temperature fluctuations during the milking process, improper use of cooling tanks, and inadequate hygiene conditions during milk collection. These factors can contribute to an increase in the total bacterial concentration, specifically total coliforms (35 °C), representing a challenge in maintaining milk's microbiological quality.

Therefore, continuous monitoring and the adoption of proper sanitary practices are essential to prevent the proliferation of undesirable bacteria in milk and ensure compliance with established quality standards.

The results presented in this study hold significant importance as they address the relevance of the physicochemical characteristics and microbial profile of raw goat milk. To date, there is a scarcity of studies dedicated to exploring this specific topic, and our analysis highlights the crucial importance of these factors in the context of goat milk. These characteristics play a vital role as they directly influence the nutritional quality, digestibility, and the production of a wide range of dairy products. Furthermore, meticulous control and in-depth analysis of these parameters prove to be essential elements in ensuring the safety and quality of goat milk-derived products. This, in turn, provides healthy and flavorful food options for consumers.

#### 4. Conclusion

From the samples analyzed in this study, it was observed that 100% of them remained in compliance with the established physicochemical parameters (pH, acidity, cryoscopy, density, fat content, protein, total solids, defatted dry solids, and ash). Concerning the microbial analysis, all samples were within the desired standards for Thermotolerant Coliforms (45 °C) (<3.0). However, a single sample exceeded regulatory limits for total bacterial concentration, specifically Total Coliforms (35 °C), which highlights the need to improve hygiene practices throughout the milking, transportation, and milk storage processes.

In this context, it is essential to emphasize the strict adherence to good management and hygiene practices in the milk production chain to ensure the quality and safety of this valuable resource and dairy products. These results underscore the importance of maintaining high hygiene standards at all stages of the process, aiming to ensure quality and compliance with established regulations, as well as meeting the expectations of consumers seeking safe and nutritious dairy products.

#### Acknowledgments

The Northeast Biotechnology Network, Graduate Program of Biotechnology (RENORBIO), to all employees of the Faculty of Veterinary Medicine the State University of Ceará (UECE) and the Laboratory of Biotechnology and Chemistry and Food Microbiology Laboratory of the Federal Institute of Education, Science, and Technology of Ceará (IFCE), Limoeiro do Norte Campus, Ceará, Brazil. Especially to the goat milk producers from the municipality of Jaguaretama, Ceará, Brazil, and to Prof. Dr. José Ferreira Nunes for financial support and technical assistance with logistics of the study.

#### References

- Alves, C. C., Silva, C. C., Lopes, R. F. A., Steffens, A. P., Assis, F. G. V., & Leal, P. L. (2023). Qualidade físico-química e microbiológica de leite cru refrigerado na Região Sudoeste da Bahia. *SaBios: Rev. Saúde e Biol.*, 18, e023004.
- AOAC. (2000). *Official Methods of Analysis*, (17th ed.), Gaithersburg, Maryland, 2005.
- Brasil, Ministério da Agricultura. (2000). *Instrução Normativa n° 37 de 31 de outubro de 2000*. Regulamento técnico de produção, identidade e qualidade de leite de cabra. *Diário Oficial da União*, Brasília, p.23, 8 nov. Seção 1.
- Brasil, Ministério da Agricultura, Pecuária e Abastecimento. (2003). *Instrução Normativa N° 62, de 26 de agosto de 2003*. Oficializa os Métodos Analíticos Oficiais para Análises Microbiológicas para Controle de Produtos de Origem Animal e Água. *Diário Oficial da República Federativa do Brasil*, Brasília, p. 14, 18 set. 2003. Seção 1.
- Coelho, M. C. S. C., Rodrigues, B. R., Coelho, M. I. S., Libório, R. C., Costa, F. F. P., & da Silva, G. L. (2018). Características físico-química e microbiológica do leite de cabra produzido em Petrolina-PE. *Agropecuária Científica do Semiárido*, 14(3), 175-182.
- Dutra, C. M. C., Bianca Svierk, B., Ribeiro, M. E. R., Pinto, A. T., Zanela, M. B., & Schmidt, V. (2014). Parâmetros de qualidade do leite de cabra armazenado sob frio. *Arquivos do Instituto Biológico*, 81(1), 36-42.
- Felisberto, N. R. O. (2022). *Diagnóstico da Bacia Leiteira Caprina localizada entre os estados da Paraíba e Pernambuco – Sobral: Embrapa Caprinos e Ovinos*, (Documentos / Embrapa Caprinos e Ovinos, 150). PDF (34).

- Gonçalves, L. S. C., Da Silva, S. X., & Beltrão, F. A. S. (2019). Elaboração e análise microbiológica de iogurte grego com leite de cabra, fermentado por kefir e adicionado de fruta. *Revista Craibeiras de Agroecologia*, 4(2).
- Ial. Instituto Adolfo Lutz. (2008). *Métodos físico-químicos para análise de alimentos*. Ministério da Saúde, (4a ed.), Brasília.
- IBGE. (2019). Sistema IBGE de Recuperação Automática - SIDRA. Censo Agropecuário 2017; Resultados definitivos. Tabela 6929 - Número de estabelecimentos agropecuários com caprinos, efetivos, venda e produção de leite, por tipologia, grupos de atividade econômica e grupos de área total. [Rio de Janeiro, 2019]. <https://sidra.ibge.gov.br/tabela/6929#n1/all/n2/2,3/n3/25,26/n9/25010,25011,26003,26004,26007,26008/v/2216,2218,2219/p/all/c829/46302/c12517/113601/c220/110085/d/v2216%200,v2219%200/l/v,p+c829+c12517,t+c220/resultado>.
- Izidoro, T. B., Pereira, J. G., Soares, V. M., Spina, T. L. B., & Pinto, J. P. D. A. N. (2013). Atividade proteolítica de bactérias psicrotróficas em leites estocados em diferentes temperaturas. *Revista Ceres*, 60(4), 452-457.
- Koche, J. C. (2011). *Fundamentos de metodologia científica: teoria da ciência e iniciação à pesquisa*. 184p. Edição digital. Vozes.
- Lima, L. R. D. N., Negreiros, I. F. L., Silva, E. F. D., & Ramos, L. S. N. (2021). Características físico-químicas do leite de cabra submetido a diferentes períodos de congelamento. *Pesquisa, Sociedade e Desenvolvimento*, 4, e23710414089.
- Mendes, C. G. (2009). *Qualidade do leite de cabra produzido no semiárido do rio grande do Norte*. Dissertação de mestrado, Programa de Pós-Graduação de Ciência Animal, Universidade Federal Rural do Semiárido, Mossoró, Brasil.
- Oliveira, F. F. (2023). *Avaliação físico-química do leite de cabra cru integral e pasteurizado produzido no cariri paraibano*. (Monografia: Bacharel em Engenharia de Biotecnologia e Bioprocessos) Universidade Federal de Campina Grande, Sumé – PB.
- Park, Y. W., Juárez, M., Ramos, M., & Haenlein, G. F. W. (2007). Physico-chemical characteristics of goat and sheep milk. *Small Ruminant Research*, 68(1-2), 88-113, 2007.
- Pequeno, A. M. (2018). *Avaliação da Qualidade de Leite de Cabras de Diferentes Genótipos*. 23 p. Trabalho de Conclusão de Curso (Monografia: Graduação em Tecnólogo em Agroecologia) – Universidade Federal de Campina Grande, Sumé.
- Pinto Júnior, W. R., Ferrão, S. P. B., Rodrigues, F. L., Fernandes, S. A. A., & Bonomo, P. (2012). Efeito do congelamento sobre os parâmetros físico-químicos do leite de cabras da raça Saanen. *Revista Caatinga*, 25(3), 110-117.
- Ramos Neto, K. X. C., Neiva Júnior, A. P., De Paiva, P. J. F., Sátiro, T. M., & Tavares, V. B. (2021) Leite de cabra: qualidade x instrução normativa nº 37/2000 do MAPA. *Extensão em Foco*, 22.
- Silva, N. et al. (1997). *Manual de métodos de análise microbiológica de alimentos*. Varela, 295.
- Statsoft. (2007). *Statistica for Window - Computer programa manual*, Versão 7.0. Statsoft, Inc.
- Verma, M., Dige, M. S., Gautam, D. S., & Rout, P. K. (2020). Análise funcional do proteoma do leite de cabras geneticamente diversas de diferentes regiões agroclimáticas. *Journal of Proteomics*, 227, 103916.