



MILK COMPOSITION OF THE CREOLE GOAT IN AN EXTENSIVE HUSBANDRY ENVIRONMENT IN A SEASONALLY DRY FOREST OF SOUTHERN ECUADOR †

[COMPOSICIÓN DE LA LECHE DE LA CABRA CRIOLLA EN UN AMBIENTE DE CRIANZA EXTENSIVA EN UN BOSQUE ESTACIONALMENTE SECO DEL SUR ECUADOR]

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SUMMARY

Background. The Creole goat (Chusca Lojana) is found in the tropical zone of the seasonally dry forest (SDF) in Loja province (southern Ecuador, South America), where 73 % of the nationwide goat population is located. **Objective.** To study the productive characteristics and the milk quality of this population because this genetic resource represents a valuable socio-economic element for the habitants of this region. **Methodology.** The production and milk quality of 198 goats, managed extensively and from different herds, were evaluated in four periodic visits, and production was recorded at the various stages of lactation, with milk samples taken for analysis using Lactoscan Milk Analyzer SA50. **Results.** It was determined that 64 % of the goats have a globular udder, 93 % have pigmented nipples, the productive life curve increases in the third calving, reaches its peak in the fourth calving and then declines ($R^2 = 0.82$), lactation duration is 140 ± 20 days, the lactation curve follows a two-period mobile trend, showing two peaks, one higher (30 days) and another of less intensity between 120-150 days coinciding with the post-weaning period, and the mean daily production is 390 ± 231 ml. Production and composition of milk are not statistically affected by biotype. The milk composition of this goat presents 5.5 ± 1.9 % Fat, 8.2 ± 0.83 % NFS, 137 ± 2.1 % Total Solids, 4.5 ± 0.47 % Lactose, 3 ± 0.3 % Protein, 0.68 ± 0.07 % Mineral Salts, and pH 6.7 ± 0.26 . **Implication.** Analyze the productive performance and quality of the milk of this goat in semi-intensive management and using shrub resources present in abundance in this ecosystem (*Croton spp*, *Ipomea carnea*), would help to improve management conditions and value this local zoogenetic resource. **Conclusions.** With the information obtained from this study, those animals with a tendency to produce quality milk in this population can be standardized for selection, management, and multiplication.

Key words: milk production; milk quality; Chusca lojana goat; zoogenetic resource.

RESUMEN

Antecedentes. La cabra criolla (Chusca lojana) es encontrada en la zona tropical del bosque seco estacional en la provincia de Loja (sur del Ecuador, Sudamérica), donde se encuentra el 73% de la población caprina a nivel nacional. **Objetivo.** Estudiar las características productivas y la calidad de la leche de esta población, pues este recurso genético representa un valioso elemento socio económico para los habitantes de esta región. **Metodología.** Fue evaluada la producción y calidad de la leche de 198 cabras manejadas extensivamente y provenientes de diferentes rebaños, se realizaron 4 visitas periódicas en donde se registró la producción en los diferentes estados de la lactación y se tomaron muestras de leche para ser analizadas mediante Lactoscan Milk Analyzer SA50. **Resultados.** Se determinó que el 64% de las cabras presenta ubre globosa, el 93% tiene pezones pigmentados, la curva productiva se incrementa en el tercer parto y alcanzando su pico en el cuarto para luego declinar ($R^2 = 0.82$), la duración de lactancia es de 140 ± 20 días, la curva de lactancia sigue una tendencia móvil de dos periodos, mostrando dos picos, uno alto (30 días) y otro de menor intensidad entre 120-150 días coincidiendo con el periodo post destete, el promedio diario es de 390 ± 231 ml. La producción y composición de la leche no son estadísticamente afectadas por el biotipo. La leche de esta cabra

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presenta: 5.5 ± 1.9 % Grasa, 8.2 ± 0.83 % SNG, 137 ± 2.1 % Solidos Totales, 4.5 ± 0.47 % Lactosa, 3 ± 0.3 % Proteína, 0.68 ± 0.07 % Sales Minerales y pH 6.7 ± 0.26 . **Implicaciones.** Analizar la capacidad productiva y calidad de la leche de esta cabra en manejo semintensivo y utilizando recursos arbustivos presentes en abundancia en este ecosistema (*Croton spp*, *Ipomea carnea*), ayudaría a mejorar las condiciones de manejo y valorar este recurso zoogenético local. **Conclusiones.** Con la información obtenida del presente estudio, aquellos animales con una tendencia a producir leche de calidad en esta población pueden ser estandarizados para su selección, manejo y multiplicación.

Palabras clave: producción de leche; calidad de leche; cabra Chusca lojana; recurso zoogenético.

INTRODUCTION

The Southern Region of Ecuador (SRE) has a variety of altitudinal floors from 100 meters to 2600 meters above sea level (m.a.s.l). There are various ecosystems, among which stands out the seasonally dry forest (SDF), an extensive area that covers the northern part of Perú and southern Ecuador in the Endemismo Tumbesino Region and includes lands above sea level until the lower foothills (1200 m.a.s.l) of the Andes Mountains with slopes up to 60°. Existing in this environment is a high diversity of flora and fauna (Aguirre Mendoza and Geadá-Lopez, 2017). The goat (*Capra aegagrus hircus*) is in this complex ecosystem where it constitutes the domestic species with the best adaptation under these environmental conditions. The Creole goat “Chusca Lojana” constitutes a zootechnical resource of high importance for the people living in the seasonally dry forest, who harness these small ruminants as a means of subsistence for its input in milk, meat, skin, and manure, and manage them under an extensive and low-tech production system.

The milk production in mammals has a noticeable difference in quantity and quality due to genetic and environmental influences (Falconer and Mackay, 1996; Haenlein, 1996). Goat milk is made of high biological value proteins and essential fatty acids, as well as minerals and hypoallergenic vitamins with high nutritional value and better digestibility, compared with other ruminants (Haenlein, 2004).

It is considered that the quantity and quality of goat milk varies from race to another, from one system management and environment to another, and by having bibliographic information regarding other genetic groups and management environments. Therefore, the objective of this study is to generate information regarding the production and

quality of Chusca Lojana goat milk handled in extensive environments in the seasonally dry forest of the RSE, identify the biotype with the best performance and the non-genetic factors that influence it; thereby allowing the availability of technical tools for selection, reproduction, and management processes of animals with a tendency to produce quality milk from this valuable local genetic resource in this seasonally dry forest of southern Ecuador.

METHODOLOGY

Study site

The study was realized in the SDF of Loja province of Ecuador in South America (Figure 1), where 73 % of the nationwide goat population is found (INEC, 2022). The milk production and quality of 198 Chuscas goats from 45 herds with different ages, number of births, and lactation stages were analyzed. Four productive and quality milk controls in every goat were realized in intervals of three weeks. In all herds, goats are managed under an extensive open-field production system, where each producer has around 15 to 30 goats released every day after milking (08H00 AM time milking) to graze for eight hours in an open field (communal areas), where bushes such as *Croton wagneri*, *Ipomea carnea*, *Cordia lutea*, *Pithecellobium excelsum*, *Lantana camara*, and trees such as *Acacia macracantha*, *Handroanthus billbergii*, *Prosopis juliflora*, *Ficus cuatrecasana*, *Caesalpinia paipai*, *Ceiba trischistandra*, constitute the daily food of these animals, returning to their barns during the afternoon. The care and handling of these goats are carried out with greater frequency by women and children, where the workload is minimal and limits itself to an irregular administration of salt, antiparasitics, and vitamins.

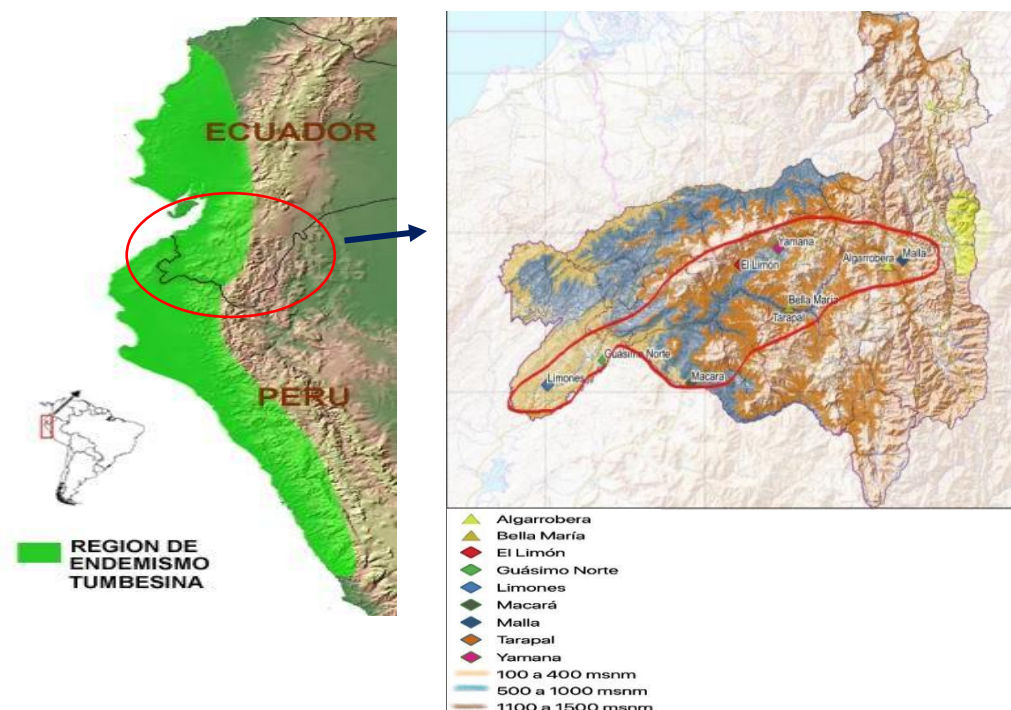


Figure 1. Geographical location in Ecuador (Loja Province-seasonally dry forest) and altitudes above sea level where the population of goats under study can be found. (Preparation: Authors)

Milk Production

In each realized visit of this study, the goats were milked thoroughly, the production volume was registered in milliliters (ml) and considering the analysis of this variable the biotype and non-genetic factors, such as the lactation stage, management location, and the number of calvings were taken into account. The productive life curve was estimate through a regression analysis grouping the daily production of the goats by the number of births.

Milk physical-chemical analysis

For the milk physicochemical analysis of the Chusca goat, a protocol was followed, where at the time of the milking of each animal, a milk sample from both mammary quarters was taken in a Falcon™ conic tube of 50 ml. The sample was then identified and placed on racks inside a refrigeration thermos for its transport to the Dairy Laboratory at the National University of Loja. Due to the distance between the sample collection and the lab, the analysis was realized 24 hours later. Then, the content of the milk fat, non-fat solids, protein, lactose, mineral salts, total solids, pH, and density were determined using a LACTOSCAN Milk Analyzer (Milkotronic Ltd. Nova Zagora, Bulgaria).

Statistical Analysis

Descriptive statistics were used to summarize the milk parameters. Continuous variables were described by means, standard deviations and coefficients of variation. To compare the parameters of milk among the biotypes we analyzed the assembled data using a one-way non parametric Kruskal-Wallis ANOVA since the data was not normally distributed as determined by the Shapiro-Wilk test. Completed data were exported to a Microsoft Excel 2016 spreadsheet for cleaning and coding and subsequently transferred to R software version 4.2.2 for subsequent Statistical analysis.

RESULTS AND DISCUSSION

The production and quality of the Chusca Goat milk in extensive management, without considering the analyzed factors (biotype, lactation stage, place, and the number of births), are shown in Table 1. Its daily volume was 390 ± 231.5 ml with a CV (coefficient of variation) of 59 %, and the fat composition, protein, non-fat solids, total solids, lactose, and mineral salts were 5.49 ± 1.9 %, 3 ± 0.3 %, 8.17 ± 0.83 %, 13.68 ± 2.1 %, 4.49 ± 0.47 %, and 0.68 ± 0.07 % respectively, the milk density was 25.68 ± 4.6 kg/m³, its conductivity was 5.13 ± 0.62 mS/cm, and the pH was 6.71 ± 0.26 . All these parameters are highly homogenous because their CV does not exceed 35 %.

It is noteworthy that production and milk quality are not statistically affected by the Chusca goat biotypes being the Chusca “turned ear” and Chusca “lion ear” (Table 2), which are the best in terms of daily milk production with 519 ml and 410 ml, respectively.

It is important to know the lactation curve in a population, in order to detect beforehand the

most potentially productive goats in the herd, and the possible mistakes in their handling (León *et al.*, 2007). Figure 2 shows the lactation duration of the Chusca goat, which is 140 ± 20 days, and presents a curve that follows a mobile trend of two peaks, one higher at 30 days and another of lower intensity between 120-150 days, which correlates with the post-weaning period.

Table 1. Production and quality of milk from extensively handled Chusca goats in the seasonally dry forest of Loja Province (n= 198 goats).

Statistic	Production ml	Fat %	DE %	TS %	D kg/m ³	L %	MS %	Protein %	C (mS/cm)	pH
Mean	390	5.49	8.17	13.68	25.68	4.49	0.68	3.0	5.13	6.71
SD	231.50	1.90	0.83	2.10	4.60	0.47	0.07	0.30	0.62	0.26
CV	0.59	0.35	0.10	0.04	0.04	0.11	0.10	0.10	0.12	0.40
Minimum	70	1.94	4.78	8.74	21.08	2.49	0.45	2.0	3.7	5.89
Maximum	1300	13.1	15.07	25.76	28.7	8.29	1.25	5.52	7.51	9.78

SD: Standard deviation; CV: coefficient of variation; DE: dry extract (non-fat solids); TS: total solids; D: density; L: lactose; MS: mineral salt; C: conductivity.

Table 2. Production and quality of Chusca goat milk according to biotype.

Biotype	Statistic	Production ml	Fat %	DE %	TS %	D kg/m ³	L %	MS %	Protein %	C (mS/cm)	pH
Lion ear	Mean	410	5.52	8.30	13.82	28.0	4.56	0.69	3.04	5	6.70
	SD	255	2.20	0.81	2.10	0.41	0.45	0.07	0.30	0.60	0.20
	CV	0.62	0.40	0.10	0.15	0.00	0.10	0.10	0.10	0.12	0.04
Short and bent ear	Mean	377	5.38	8.15	13.56	27.42	4.49	0.68	3.0	5.12	6.70
	SD	220.50	1.81	0.82	2.03	0.37	0.47	0.07	0.30	0.62	0.30
	CV	0.59	0.34	0.10	0.15	0.00	0.10	0.10	0.10	0.12	0.04
Muca	Mean	400	5.83	8.14	13.97	27.22	4.48	0.67	2.99	5.23	6.70
	SD	252	1.90	0.97	2.20	0.10	0.53	0.08	0.36	0.57	0.30
	CV	0.63	0.32	0.12	0.16	0.01	0.12	0.12	0.12	0.11	0.04
Turned ear	Mean	519	6.15	8.07	14.22	28.66	4.40	0.67	3.0	5.38	6.70
	SD	250	2.50	0.60	2.50	2.20	0.40	0.05	0.23	0.69	0.21
	CV	0.48	0.40	0.08	0.18	0.22	0.08	0.05	0.08	0.13	0.03

SD: standard deviation; CV: coefficient of variation; DE: dry extract (non-fat solids); TS: total solids; D: density; L: lactose; MS: mineral salts; C: conductivity. (P>0.05)

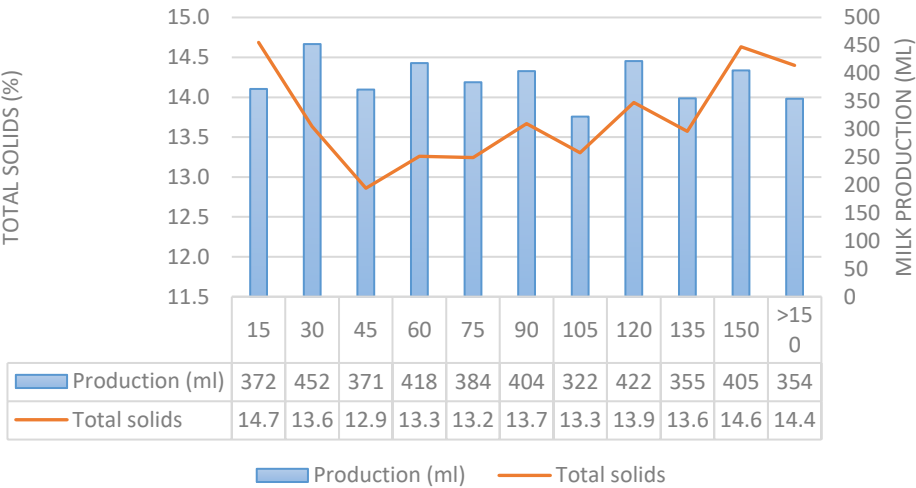


Figure 2. Average milk production and total solids during lactation stage of the Chusca goat.

Analyzing Figure 2, it is possible to highlight the negative correlation between milk yield and composition since lower production has higher solid contents (fat, protein) and vice versa. In the same way, as lactation progresses, milk components increase, especially fats, non-fat solids, and total solids; this behavior is also noted by Prasad and Sengar (2002) and Salvador and Martinez (2007).

In Figure 3, the productive life curve of the Creole goat is observed where milk production rises as the number of births increases, reaching its highest peak in the fourth birth with daily milk production of 466 ml, then declines ($R^2 = 0.82$).

In the present study it was determined that the production and composition of milk of the Chusca goat is influenced by the biotypes, and the “turned ear” is the one that presents a better quality of milk than the other biotypes. In this regard, Salvador and Martínez (2007), in their review article about factors that affect the production and composition of goat milk, mention genetics as the principal intrinsic factor because there are breeds and within them groups (biotypes) that produce more milk than others.

In our study, the Chusca “turned ear” is the goat that presents a better milk quality than the other biotypes. Another extrinsic factor, according to Buxadé (1996), is the production system because in developed countries the predominant system is usually intensive, which involves an increase in production; whereas, in

developing countries the opposite occurs, so their native breeds tend to be poor producers of milk. Complementing what was stated by those authors, in the goat population of the present study, due to the extensive and poor technical management, females become pregnant at an early age, thus affecting their productive performance.

When analyzing the length of lactation of this goat, it is low compared to that expressed by Ferro *et al.* (2017) in the Toggenburg and Saanen goats in semi-intensive systems of 206 days, and in the Murciano-Granadina goat at 210 days (Inostroza *et al.*, 2020). But it has its justification if we analyze what is stated by Cruz (2013), that lactation duration depends on the breed and the environmental conditions provided to animals. The two lactation peaks presented by the goat of the present study, show a persistent curve after weaning, and are different from what was stated by Agraz (1989) and Cruz (2013), about a maximum production between the seventh and twelfth week.

After analyzing the different physicochemical components of this milk, it was possible to agree with what was stated by Haenlein (1996); Chilliard *et al.* (2003); Morand-Fehr (2005); Hernández and Bedolla (2008); Dantas *et al.* (2008), and Djebli *et al.* (2020), that the variation of these components and the production are due to more than the genetic factor, because there are also the different management behaviors, feeding, lactation stage and, even the sanitary state of the udder.

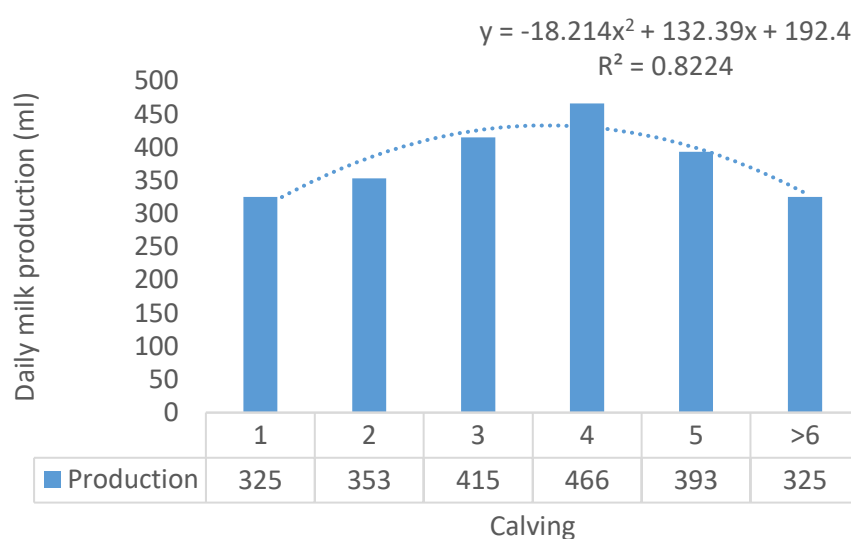


Figure 3. Productive life curve of the Chusca Lojana goat.

By analyzing each of the components of milk, the fat is the most variable (CV:0.35) and it is heavily influenced by the feeding the animals received, whereas lactose and minerals are the most stable (Hernández and Bedolla, 2008). The state of lactation influences the levels of total solids (Figure 2), as they are higher in the colostrum and decrease until 45 days to increase again as milk production decreases. This behavior shown by the Chusca goat also is noted by Agraz (1989); Buxadé (1996) and Haenlein (1996) in their written works about goat handling in general.

Regarding the protein content in the milk of this goat in its different biotypes, the value of 3 % is similar to what was stated by Kaberia *et al.* (2003) in Kenyan dairy goats, but lower than those noted by Prasad and Sengar (2002) in the Indian Barbari breed and its crosses: Barbari × Jamunapari, Barbari × Beetal and Barbari × Black Bengal with values 3.7, 3.8, 3.4, and 3.9 % respectively, or in that found in Nubian crossbred goats × local Algerian breed with a protein value of 3.4 % (Djebli *et al.*, 2020).

The milk density can be explained as a function of the fat content and non-fat solids, with a positive correlation between these elements, in that their values increase at the same time that the fat concentration increases (Buxadé, 1996; Djebli *et al.*, 2020; Lupien, 1995). In the present study, the milk density within the different Chusca goat biotypes ranges between 27.2 to 28.7 kg/m³, meaning that these results are below those obtained by Djebli *et al.* (2020) in the Algerian crossbreed goat milk with 35.8 ± 2.92 kg/m³.

When analyzing lactose, it is important to mention the studies carried out on sheep and goats by Leitner *et al.* (2004) and Morand-Fehr *et al.* (2007), where it is noted that lactose levels are affected by the hygienic aspect of the milk, so with the presence of clinic and subclinical mastitis, as well as during the lactation peak, the levels drop. In this goat population, the media level was 4.49 ± 0.47 %, a value that is within the ranges (4.4 to 4.7 %) stated by Buxadé (1996) and cited by Cruz (2013).

Djebli *et al.* (2020), stated that the salt mineral content and conductivity of milk are two parameters with a positive correlation, and the conductivity will increase as a higher content of somatic cells in the milk becomes available. According to Hernández and Bedolla (2008), milk with a clinical or subclinical mastitis has an increase in Na and Cl ions, hence the conductivity rises. Cruz (2013) notes that goat milk has a mineral salt content between 0.5

and 0.8 %, and the Chusca goat milk is within this range (0.68 ± 0.07 %). According to Luquet *et al.* (1991), the electrical conductivity of goat milk could vary between 4.9 to 13.09 mS/cm at 25 °C. The present study obtained a conductivity of 5.13 ± 0.62 mS/cm, which shows the great adaptation and rusticity of this creole goat, that in despite of the hard conditions of the seasonally dry forest and extensive and poor technical management, its milk is healthy and clean. Moreover, the positive aspects of this goat to highlight are the globose shape of its udder and its pigmented teats, which can be found in 64 % and 93 % of the population, respectively.

Concerning the pH of the milk, Buxadé (1996) points out that values which range between 6.3 and 6.8 can be considered normal; in the present study, the value is 6.71 ± 0.26 , so it is possible to note that this milk presents an ionic reaction close to neutrality.

The results of productive curve of the Chusca goat are similar to those reported by Milerski and Mares (2001), where there was an increase in milk production around the third and fourth years. Similarly, Salvador and Martínez (2007) claimed that the goat, like other domestic ruminants, produces little milk during the first years of life, and those authors concluded that there is less milk production in the first lactations, and as the number of births rises until the fourth one, the production and content of dry material, non-fat solids, protein, and fat also increase.

CONCLUSIONS

As there are differences in the production and above all the milk composition across the different Chusca goat biotypes, this information will allow the producers and technicians to standardize it for selection, handling, and multiplication purposes of the animals, with a tendency toward high quality milk production within this population.

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Declaration of Competing Interest: The authors declare no conflicts of interest.

Compliance with ethical standards: The investigation had approbation of Bioethical and wellness animal committee of the Veterinary Medicine school, National University of Loja (CBEBA-UNL 011-2021) and also had the authorization and presence of the owners in the collection of milk samples of each animal.

Data Availability Statement. Data can be available from the author upon a reasonable request.

Author contributions statement (CRediT).

E.L. Aguirre - conceptualization, methodology, supervision, project administration, funding acquisition, writing—original draft preparation. **D.R. Armijos** - software, formal analysis, validation. **R. Bustillos** - data curation, visualization, writing—review and editing. **M.V. Puchaicela** - investigation. **A.B. Avila** - investigation. **P.A. Pineda** - investigation. **J.P. Riofrio** - investigation.

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