



Effect of climatic factors in the physicochemical and microbiological quality of bovine milk

Efecto de los factores climáticos en la calidad fisicoquímica y microbiológica de la leche bovina

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ABSTRACT

Milk is a food that has a great importance in society because, for its commercialization, payment for quality is used, where the physical-chemical and microbiological parameters determine the price of milk. Therefore, the objective of this research was to determine the influence of environmental factors (temperature, rain precipitation, humidity, solar radiation) on the physicochemical and microbiological quality of bovine milk in the zones of the San Martín Region - Peru. For its samples of milk were gathered in every zone of study and were analyzed to obtain his characteristics of density, acidity, fat, protein, solid total, aerobic mesophiles and numbering of coliforms. Duncan test at 5% was used to compare means, in addition Spearman correlation was performed in order to determine the degree of association between the variables of physicochemical and microbiological quality of milk with environmental factors. Concluded that environmental factors affect the density, fat and thus in the number of total solids in milk. Besides environmental factors directly affecting the numbering of aerobic mesophilic, especially solar radiation and temperature.

Keywords: Environmental factors; bovine milk; physicochemical and microbiological quality.

RESUMEN

La leche es un alimento que tiene una gran importancia en la sociedad; en su comercialización se utiliza el pago por calidad, donde los parámetros físico- químicos y microbiológicos, determinan el precio de la leche. Por tal motivo el presente trabajo de investigación tuvo como objetivo determinar la influencia de los factores ambientales (temperatura, precipitación, humedad, radiación solar) en la calidad fisicoquímica y microbiológica de la leche bovina en tres zonas de la Región San Martín - Perú. Para ello se recolectaron muestras de leche en cada zona de estudio y fueron analizadas para obtener sus características de densidad, acidez, grasa, proteína, sólidos totales, mesófilos aerobios y numeración de coliformes. Se utilizó la prueba de Duncan al 5%, además de la correlación de Spearman con la finalidad de determinar el grado de asociación entre las variables de calidad fisicoquímicas y microbiológicas de la leche con los factores ambientales. Concluyendo que los factores ambientales influyen en la densidad, materia grasa y cantidad de sólidos totales presentes en la leche. Además, los factores ambientales afectaron directamente a la numeración de aerobios mesófilos, en especial la radiación solar y la temperatura.

Palabras clave: Factores ambientales; leche de bovino; calidad fisicoquímica y microbiológica.

1. Introduction

In the last two decades, the global community has studied the effect of climate on animal production, making important advances in the understanding of physiological aspects and animal behavior under thermoneutral and climatic stress conditions; and its impact on local, regional and national

development (Arias *et al.*, 2008).

Among the climatic factors that restrict or determine animal production, temperature, relative humidity, solar radiation and hours of sunstroke in tropical conditions is very important because it determines the development of physiological mechanisms of thermal regulation, to the

detriment of the level productive (Echeverri and Restrepo, 2009; González et al., 2004; Aharoni et al., 2002; Dahl et al., 2000; Valle, 1998).

In the case of dairy cattle, the physicochemical and microbiological quality of fresh milk is affected by environmental factors such as: environmental temperature, relative humidity, wind, solar radiation, rain and altitude. The effects of climate on animal production are direct and indirect. Direct because they affect the energy needs of animals and indirectly since they influence the availability of fodder (Campabadall, 2012; Celis and Juárez, 2009). Under tropical conditions, temperature and precipitation are the most determining meteorological elements in the effect that time produces on animals with zotechnical purposes. However, other elements such as solar radiation and relative humidity can play an important role when they have maximum values in combination with other factors (Arias et al., 2008).

In the San Martín region, livestock is one of the main economic activities that is extensively developed with improved Brown Swiss and Holstein breeds crossed with Gyr for milk and meat production, with an improved grass-based diet (*Brachiaria brizhanta*, *Cameroon grass*, *King grass*) and legumes (*Centrosema*, *Stylosanthes*). The production of milk produced in this region has as markets the Glass of Milk Program, through the Municipalities to the organized committees, and in a smaller proportion to the elaboration of dairy derivatives such as cheeses, yogurt and pasteurized milk, taking into account that for the elaboration of these products it is necessary to have a good quality milk, that is, with levels of fat, density, proteins and total solids that increase the yield of the production.

For this reason, based on the above mentioned in this present investigation, it aims to stimulate and strengthen the development of specific tools to facilitate decision-making, on aspects of livestock-environment, designed to adapt general principles of improved interaction management, especially, to the regional needs and conditions of San Martín. For them it is tried to analyze the effect that the environmental factors could have on the quality of the bovine milk that is produced in three milk zones of the San Martín Region, for this we will be framed to the areas of Alto Mayo, Bajo Mayo and Huallaga Central; setting the following objectives

2. Material and methods

The research project was developed in the

Research and Development laboratory of the Faculty of Agroindustrial Engineering of the National University of San Martín-T, District of Morales, Province and Department of San Martín.

Methodology

The experimental unit was 1 liter of milk, for each sampling point, which was distributed for the different analyzes (physicochemical and microbiological). The samples were collected from the collection centers in the aforementioned areas for four (04) months (August to November). These dairy samples were obtained from cattle of the Brown Swiss and Holstein breeds crossed with Gyr, aged between 2.5 and 4 years, since these breeds are predominant in the study areas. The type of milking used was manual and in some cases mechanized. The feeding of this cattle was based on improved grasses (*Brachiaria brizhanta*, *Cameroon grass*, *King Grass*) and legumes (*Centrosema*, *Stylosanthes*), in addition to food preparations containing soy cake, ground corn, rice powder, wheat bran, common salt, mineral salt, calcium and magnesium in the three study areas.

The milking of the cattle was carried out in the morning hours (4:00 am - 6:00 am), and the sampling was carried out from 6:30 in the morning in each collection center and / or farm, performing the titratable and other acidity and acidity analyzes in situ, then the samples were conditioned in sterile containers and with cold systems to be sent to the SAC Technical Advisory Society laboratory for the missing physicochemical and microbiological analyzes.

Table 1 presents the physicochemical and microbiological analyzes of bovine milk that were performed using methodologies validated and recommended by the Peruvian Technical Standard (NTP) and International Organization for Standardization (ISO).

For the proximate physical analysis, the density (NTP 202.001:2016), acidity (NTP 202.116:2008), fat (NTP 202.126:1998), proteins (NTP 202.119:1998) and total solids (NTP 202.118:1998) measurements were conducted in line with the methodologies validated and recommended by the Peruvian Technical Standards (NTP). The microbiological analyses of total aerobic mesophiles (ISO 4833:2003) and Coliform count (ISO 4832:2006) were conducted following the methods of the International Organization for Standardization (ISO).

Table 1
Description of the physical and chemical variables of fresh milk

Zone	Density (g/ml)	Acidity (%lactic acid)	Fat matter (g/100g)	Protein (g/100g)	Total solids (g/100g)
Alto mayo	1.0305 ± 0.0006	0.1575 ± 0.0066	4.2013 ± 0.6307	2.8933 ± 0.1763	12.7850 ± 1.1335
Bajo mayo	1.0298 ± 0.0009	0.1563 ± 0.0048	3.8450 ± 0.9048	2.9575 ± 0.2839	12.4013 ± 1.5651
Huallaga Central	1.0283 ± 0.0006	0.1513 ± 0.0117	3.1775 ± 0.9449	3.0063 ± 0.4200	10.9838 ± 1.5437

The meteorological information was obtained through the SENAMHI (National Service of Meteorology and Hydrology of Peru) and taken from the Moyobamba, Cuñumbuque and Bellavista meteorological stations. The parameters reported were: temperature, relative humidity and solar radiation. In addition, statistical procedures will be carried out through the use of the SAS statistical program (System Analysis Software), version 9.0, EE. UU.

For the data analysis, descriptive statistics such as averages (\bar{x}), standard deviation (SD), maximum value and minimum value were applied to determine the behavior of the different variables evaluated as density, acidity, protein, fat and total solids. For the comparison of means, check the Duncan test at 5%.

Statistically, a Spearman's correlation was made in order to determine the degree of association between the variables of physicochemical and microbiological quality of milk with environmental factors, using the statistical program Statistics version 10. Spearman's rho was calculated using the equation 1:

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2-1)} \quad (1)$$

Where: r_s = Spearman rank correlation coefficient; d = Difference between the ranges (X minus Y); n = Number of data.

In addition, an analysis of variance was carried out for each of the quality characteristics, including as meteorological sources the meteorological parameters to be analyzed. The model was as follows:

$$Y_{ijklsm} = \mu + T_i + P_j + H_k + B_s + e_{ijks} \quad (2)$$

Where: Y_{ijklsm} = Dependent variable (density, acidity, protein, fat, total solids); μ = Efecto promedio; T_i = Efecto de la temperatura (i); P_j = Efecto de la precipitación (j); H_k = Efecto de la humedad relativa (k); B_s = Efecto de la radiación solar (s); e_{ijks} = Error experimental.

3. Results and discussion

Physicochemical and microbiological characteristics of bovine milk

Table 1 reports the descriptive statistics of the physical and chemical variables of bovine milk samples from the dairy areas of Alto Mayo, Bajo Mayo and Huallaga Central in the San Martín

Region. The descriptive statistics for bacteriological quality in samples of bovine milk in the areas of Alto Mayo, Bajo Mayo and Central Huallaga of San Martín Region are presented in Table 2.

Table 2
Description of the microbiological variables of fresh milk

Zone	Mesophilic (1000 UFC/ml)	Coliform numbering (UFC/ml)
Alto mayo	113±91.041	11.043±18.923
Bajo mayo	1.147±1.377	70.730 ±166.841
Huallaga Central	3.432±2.946	6.930.273±18.168.919

From the results obtained, in Bajo Mayo and Huallaga Central areas report values above the microbiological requirement demanded by the NTP 202.001 (2016), which is 1×10^6 cfu/mL, so they can be considered of low bacteriological quality.

The causes of these reports are largely due to bacterial contamination of milk residues that have remained on the surface of the implements used in obtaining and storing milk, to dirty or non-sanitized udders prior to milking and non-refrigeration. rapid milk in addition to poor hygienic conditions of the stables, milking sites, lack of hygiene in the hands of operators, lack of implementation of hygiene practices prior to milking as the performance of nipple hygiene practices, bacteriological quality of the water, drying of the nipples and handling of the calf in dual-purpose systems, an inadequate routine of cleaning and disinfection of the containers used in milking, lack of implementation of cold networks for the preservation of milk (Calderón, 2011; Alpina, 2012).

Correlation between bovine milk quality parameters and environmental factors using Spearman

The correlation between quality parameters and, the environmental and meteorological parameters studied is presented in Table 3. One can observe that the Spearman's Rank Correlation Coefficients rho (R) range from values under -0,5 to over +0,5 and some between those values. These results show that correlations had statistical significance between very narrow inverses and mildly strong directs. These results may be due to the different

agroclimatic conditions of the study areas that have an effect on both the production and the quality of milk (Rajur et al., 2019).

In the case of solar radiation and ambient temperature, the results show a strong negative (inverse) correlation, i.e. the higher both solar radiation and ambient temperatures get, the lower the density values. Moreover, when we pay attention to the correlation between relative humidity and precipitation versus density, we can see a rho (R) value of 0,676018, which indicates a strong and direct correlation. The higher the relative humidity and precipitation values get, the higher the density values of milk are. Both results are in line with those reported by Zeng et al. (2017), which stated that climatic variables are factors that affect the quality of milk. The same study indicates that, in colder regions, those variables that are part of total solids (fats, minerals, lactose, among others), will also have a higher concentration and, therefore, a higher density (Bustamante-Córdova et al., 2016). Regarding the acidity in milk and its relation to solar radiation and environmental temperature, the value of R (-0.247628) indicates that the correlation between these parameters is moderately weak inverse and against relative humidity and precipitation; similarly, acidity has a moderately narrow positive correlation (+0.247628). Relative humidity and precipitation have a positive (direct) correlation moderately strong with the amount of fat; now if we analyze the solar radiation and the environmental temperature, they have a slightly narrow (inverse) negative correlation; this indicates that at higher rates of solar radiation and temperature, the amount of fat in the milk will be less.

The environmental factors and their variations did not correlate either directly or indirectly with the percentage of protein present in the bovine milk of the dairy areas under study, since their R values were close to zero (-0.118 and + 0.118). Regarding the correlation between solar radiation, ambient temperature and total solids, we can indicate that the association was moderately strong (inverse) negative. Now if we compare relative humidity and precipitation, these parameters had a moderately strong (direct) positive association with the amount of total solids; this indicates that at lower temperatures and solar radiation, solids tend to increase slightly in milk and vice versa.

The correlation of the mesophilic aerobic count in milk with solar radiation and environmental temperature, reports a strong (direct) positive association; this is that while these environmental factors increase, the amount of mesophilic aerobes in milk will also rise, therefore this parameter is strongly linked to the quality of the water used in dairy cattle breeding, milking hygiene, the hygiene of milking personnel, the washing of equipment and utensils that get in contact with milk, as well as milk cooling (Brousett-Minaya et al., 2015). Meanwhile, relative humidity and precipitation have a strong inverse association with the count of mesophilic aerobes in milk.

Regarding the numbering of coliforms in milk and its relation to solar radiation and ambient temperature, the value of R (0.3907) indicates that the correlation between these parameters is moderately weak directly and against relative humidity and precipitation, coliform numbering has a moderately narrow negative correlation (-0.3907).

Table 3

Spearman's correlations between quality parameters and environmental factors

Variables	Solar Radiation	Relative Humidity	Annual Precipitation	Environmental Temperature
Density	-0.676018	0.676018	0.676018	-0.676018
Acidity	-0.247628	0.247628	0.247628	-0.247628
Fat matter	-0.457269	0.457269	0.457269	-0.457269
Protein	0.118005	-0.118005	-0.118005	0.118005
Total solids	-0.501412	0.501412	0.501412	-0.501412
Aerobic mesophilic	0.634000	-0.634000	-0.634000	0.634000
Coliform numbering	0.390721	-0.390721	-0.390721	0.390721

Table 4

Results of the degree of significance between quality parameters and environmental factors

Variables	Solar Radiation	Relative Humidity	Annual Precipitation	Environmental Temperature
Density	0,000288 **	0,000288 **	0,000288 **	0,000288 **
Acidity	0,243354 NS	0,243354 NS	0,243354 NS	0,243354 NS
Fat matter	0,024668 *	0,024668 *	0,024668 *	0,024668 *
Protein	0,582891NS	0,582891NS	0,582891NS	0,582891NS
Total solids	0,012554*	0,012554*	0,012554*	0,012554*
Aerobic mesophilic	0,000879 **	0,000879 **	0,000879 **	0,000879 **
Coliform numbering	0,059055 NS	0,059055 NS	0,059055 NS	0,059055 NS

* Significant difference ($p < 0.05$); ** Highly significant difference ($p < 0.01$); NS: Not significant ($p > 0.05$).

Table 4 shows the results of the degree of significance between the quality parameters of fresh milk and environmental factors by means of Spearman's correlation probability. According to these results, the density and count of mesophilic aerobes were highly influenced by environmental factors ($p < 0.01$), the percentages of fat and total solids were significantly influenced by the variations that the meteorological parameters had ($p < 0.5$), that is to say both the ambient temperature, solar radiation, precipitation and relative humidity make the values of fat and total solids in the milk affected and report debatable results. Finally, environmental factors (solar radiation, relative humidity, precipitation, and ambient temperature), however, did not exert a significant effect on acidity, protein percentages and coliform numbering ($p > 0.05$).

4. Conclusions

The environmental factors affect the physical and chemical quality of the milk, so we have that the solar radiation and the environmental temperature influence the density, fat matter and therefore the amount of total solids present in the milk, having negative associations (inverse) Narrow: At higher temperatures and solar radiation, levels of density, fat and total solids decrease in bovine milk. Relative humidity and precipitation have close positive (direct) correlations in the values of density, fat and total solids in bovine milk. However, these meteorological parameters had little or almost no influence on the acidity and percentage of protein in the milk of the three milk zones of the San Martin Region.

The environmental factors had an influence on the microbiological quality of bovine milk, that is, they directly affected the numbering of mesophilic aerobes, especially solar radiation and temperature, and so in the higher temperature zones (Central Huallaga), results were obtained high aerobic mesophilic in milk. As for the numbering of coliforms, these were not influenced by environmental factors.

The dairy zone of Alto Mayo, due to its environmental conditions and its altitude above sea level, turns out to be the best area for production.

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