Physicochemical and statistical analysis of a dairy production

N Hurtado-Lugo¹, A Rincon¹, and M Ceron-Muñoz²

¹ Grupo de Investigación GI@DS, Universidad Francisco de Paula Santander, Seccional Ocaña, Colombia
² Grupo de Investigación en Agrociencias, Biodiversidad y Territorio GAMMA, Universidad de Antioquia, Medellín, Colombia

Email: nhurtado.lugo@ufpsd.edu.co

Abstract. The objective of this study to evaluate by physicochemical and statistical analysis the compositional quality of milk based on the constituents of fat, protein, and non-fat solids in dairy cattle located in the “Ocaña, Norte de Santander, Colombia”. Having a total of 905 dairy controls in 15 females with double milking/day throughout breastfeeding, the descriptive statistics were subsequently calculated. The average values for the percentage of fat, protein, and non-fat solids were 4.1%, 2.9%, and 8.2% with a standard deviation of 0.957, 0.210, and 0.555 respectively. The physical and chemical components of milk were found in the range stipulated by studies focused on milk yield and quality. On the other hand, it is concluded that the variation obtained in the constituents, is within the expected for the region and the species. It is also suggested that the variations of these constituents may be associated with factors such as the stage of lactation and quality of forages in winter and summer.

1. Introduction

A variety of productive and management systems with multiple levels of influence on the market economy, located in different climatic regimes, types of soils and plant life [1], are included in bovine livestock highlighting milk as one of the main raw materials in production systems along with meat. Colombian legislation specifically (decree 616) defines milk as a product of mammary secretion from mammalian animals, which is obtained through one or more complete milking, without any addition, intended for consumption in liquid form or for further processing [2]. Milk is described as a staple food, as it is considered basic in the human diet [3] and in high demand for its high nutritional value [3,4], which is reflected in its components; using it directly and transforming it to obtain products. Its industrialization has developed on large scales, allowing a greater number of derivatives ideal for human nutrition to be obtained every day [3]. These characteristics of the market have directly influenced so that the term milk production is used and developed in all parts of Colombia and the world; however, the national supply in certain sites does not meet the requirements of the raw material, being not very competitive because they fail to meet the demand for food and its derivatives [5], to which the diversity of climate with those that count each region and the bovine races destined to the milk production, because they are usually diverse in the course of the year (Climate) and multiple productive systems (Races). Given the variability of the climatic conditions of the country during the times of the year, livestock farms acquire their characteristics by region [6], it is important then, to investigate the physical and chemical properties and their variations over time [7], promoting greater efforts to understand the production process and leading to analyze each animal productively. It is
necessary to emphasize that milk yield is obtained through the interaction of the environment and environment.

Accordingly, for the acquisition and improvements of the raw material, the animals must be genetically evaluated, it is important to carry out daily production records, since these allow me to indicate the possible genetic potential of the animals [8], despite the productive records also allow the evaluation of milk yield and quality. This is a variable, which has ceased to be a competitive priority since it has become an indispensable requirement to compete in the market [9].

In Colombia, the assessment of dairy components has taken considerable importance, so much so that today resolution 0017 [10], is in force, which stipulates payments to suppliers according to the content of protein, fat, solids not total fatty and solid that are present in the milk; and other aspects such as hygienic and sanitary quality; reason why the use of healthy cattle, under good management and feeding conditions, guarantee a product with optimal physical-chemical characteristics for the demanding markets. Each physical chemical property of milk is determined by the contribution of its constituents, these properties vary with the composition. Some of the physical properties of milk depend on total of components: density. Others depend on dissolved substances, freezing point and others on ions, pH, etc. [7].

The following work focused on the study of milk yield and quality, from the point of view of composition and physico-chemical properties as well as its variations, necessary to determine its nutritional composition, followed by the growing interest in payment systems by the industry, dairy based on components [11].

2. Methodology
The information used in this study was taken from the bovine production system of the “Universidad Francisco de Paula Santander”, located in “Ocaña” in the department of “Norte de Santander, Colombia”, with a latitude of 8°14’15.8″N 73°21’21.7″ at 1150 meters above sea level and an average temperature of 23 ºC. The system has 39 animals, of which 905 samples of milk from 15 cows, 12 of the Girolanda breed, 2 Jersey / Holstein, and 1 Cebu / Holstein from second to seventh birth were analyzed. The females studied underwent a daily double milking, obtaining samples permanently, except Sundays.

2.1. Collection and analysis of information
For the collection of phenotypic information, 75 ml of milk per animal were taken, then, with the help of the pH meter, the pH is determined according to the Association of Official Agricultural Chemists (AOAC) 981.12 method [12] and then with the support of the Ekomilk portable analyzer, physicochemical parameters such as protein, density, freezing point, fat, and non-fatty solids were determined; proceed to organize and analyze the information in the Excel platform, utilizing descriptive statistical analyzed.

One-way analysis of variance (ANOVA) was performed with milk productions for each month of lactation, using the general linear models (GLM) procedure of the statistical analysis software (SAS) package [13]. In the statistical analysis, the effects of the month, year of birth, the interaction month by year, and the age of the cow at birth (covariate) were considered.

3. Results and discussion
The means obtained for protein, fat and non-fat solids were 2.9%, 4.1% and 8.2% respectively, therefore when evaluating them according to the literature [14,15], it is observed that the average of each component is within the parameters expected for the species.

The kurtosis and the coefficient of asymmetry for each study variable, corresponds to 1.831 - 0.640 for fat, 111.415 - 3.463 for protein and 13.855 - 1.843 for non-fat solids, determining that there is a leptokurtic distribution for all the variables studied and an asymmetry towards right for most of them only except for non-fatty solids, which have a negative asymmetry to the left.
In Figure 1, the trajectory of the percentage of fat is observed, which varies throughout the months studied. Estimating that the highest and lowest value was presented in October \((4.3 \pm 0.99)\) and April \((4.00 \pm 0.95)\), respectively. Table 1 shows the components analyzed and the established parameters. It was also observed that the change in the trajectory of fat production presented an expected phenotypic variation for the species. Some authors point out that fat yield in crossed dairy cattle may vary depending on the stage of lactation, race and ambient temperature [16].

Table 1. Components analyzed.

| Parameters          | Fat% (DS)       | Protein% (DS)  | SNG% (DS)  |
|---------------------|-----------------|----------------|------------|
| Average             | 4.1 ± 0.957     | 2.9 ± 0.210    | 8.2 ± 0.555|
| Typical error       | 0.018           | 0.004          | 0.011      |
| Sample variance     | 0.921           | 0.004          | 0.308      |
| Kurtosis            | 1.831           | 111.415        | 13.855     |
| Asymmetry coefficient| 0.640          | 3.463          | -1.843     |
| N                   | 905             | 905            | 905        |

Note. Where DS equals the standard deviation; SNG: Non-fat solids and N: Total samples.

On the other hand, authors whose work has similarity with the one made, affirm that the age and the number of lactations influence the fat present in the milk [17]. In the kurtosis values for milk and fat yield, a leptokurtic distribution is observed in October (Oct) 1.516, November (Nov) 1.811, February (Feb) 3.031, March (Mar) 0.901, and April (Apr) 3.523. This means that the fat data are grouped around the average generating greater reliability, while in December -0.049 the distribution was of the plastic-type presenting a value lower than zero, which indicates that these data have been dispersed from the arithmetic average generating lower reliability of the data.

In the same way, the asymmetry coefficient for the data corresponding to the fat in bovine milk yield was analyzed during the months of study: October 0.188, November 0.353, December 0.0041, February 1.445, March 0.674 and April 1.187. Determining that the values of this variable have a positive asymmetric distribution in all the months of the treatment, taking an inclination towards the right of the arithmetic mean.

In Figure 2, it can be seen that the trajectory of the percentage of protein yield varies throughout the months studied. Estimating that the highest and lowest value is presented in October \((3 \pm 0.165)\) and April \((2.8 \pm 0.152)\) respectively. It was also observed that the change in the trajectory of protein yield presents an expected phenotypic variation for the species. Protein yields in crossed dairy cattle may vary depending on the environmental conditions, presenting differences in the percentage values thrown in the winter and summer seasons respectively, so they ensure that these differences would be associated with caloric stress [18]. The kurtosis found for protein yield during October (Oct) 1.593, November (Nov) 1.878, December (Dec) 269.934, February (Feb) 2.766, March (Mar) 33.183 and April (Apr) 12.402, have a leptokurtic distribution, as they are grouped around the arithmetic mean.

In the same way, the asymmetry coefficient for the data corresponding to bovine protein yield was analyzed during the study months: October -0.615, November -0.112, December 13.013, February -
0.859, March 0.324 and April -2.099. This study finding that during December and March, a positive asymmetry was presented with an inclination towards the right, while in the other months the asymmetry was negative with an inclination towards the left of the arithmetic mean.

In Figure 3, the trajectory of the percentage of non-fatty solids over the months studied is observed. Estimating that the highest and lowest value is presented in October (8.7 ± 0.547) and April (7.9 ± 0.422). It was also observed that the change in the trajectory of the non-fatty solids yields presents an expected phenotypic variation for the species [19]. Indicated that the concentration of non-fatty solids yields, and other dairy components remain influenced by multiple factors among which are mainly those of a nutritional nature.

The kurtosis values for non-fatty solids of bovine milk, during October 86.607, November -0.139, December 11.596, February 8.484, March 7.791 and April 12.119, finding a leptokurtic distribution in October, December, February, March, and April. Analyzing that the data for this variable are grouped around the arithmetic mean, generating greater reliability, while during November a plastic distribution was observed so that the data are dispersed in the arithmetic mean. Next, the asymmetry coefficient was analyzed for the data corresponding to the non-fatty solids of bovine milk, during October -5.885, November -0.454, December -1.367, February -1.778 -1.778, March -1.969 and April -2.099, finding a negative asymmetry, which reflects an inclination of outliers to the left of the arithmetic mean.

Regarding the average density of milk, it ranges between 1.027 and 1.033 g/ml between temperature ranges of 15 °C to 23 °C, data similar to those suggested in decree 616. [2]. However, it is important to clarify that the density varied in some months since there were changes in the manifestation of components in milk. However, the temperature makes changes in the presence of both components and density, since increasing temperature decreases the density due to the expansion of water. [20]. This fact may suggest that the freezing point was close to the accepted range [2] with an average value of -0.520 °C. Furthermore, it was observed that the freezing point did not influence the density. The pH was kept in the range of 6.6 to 6.8, which allows us to analyze that this physical parameter did not directly influence the changes or fluctuations of components with respect to the passing of the months [7].
4. Conclusions
There are variations in the composition of the milk constituents in the animals studied during the different months of the year; where the variation of the constituents analyzed may be associated with factors, such as the stage of lactation and the quality of the forages in winter and summer. The physical and chemical components of milk were found in the range stipulated by studies focused on milk quality, concluding that dairy components were directly influenced by the factors mentioned above.

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