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Elaine Ralmenia Nunes Rodrigues
Department of Sciences, University Center Brasília de Goiás, São Luís de Montes Belos, Goiás, Brazil

Irisnádia Guimarães de Faria
Department of Sciences, University Center Brasília de Goiás, São Luís de Montes Belos, Goiás, Brazil

Edvande Xavier dos Santos Filho
Department of Sciences, University Center Brasília de Goiás, São Luís de Montes Belos, Goiás, Brazil

Corresponding Author:
Edvande Xavier dos Santos Filho
Department of Sciences, University Center Brasília de Goiás, São Luís de Montes Belos, Goiás, Brazil

Production system and milking structure influence on the quality of milk from farms in the mesoregion of central Goiás, Brazil

Elaine Ralmenia Nunes Rodrigues, Irisnádia Guimarães de Faria and Edvande Xavier dos Santos Filho

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Abstract
Dairy production represents a source of income for families living in rural areas of Brazil. The state of Goiás generates about 2.5 billion liters per year of the total national milk production. Therefore, it is necessary to identify the limiting factors of milk quality. Thus, this cross-sectional work aimed to relate aspects of dairy production, milk composition and milking structures from 20 farms in the mesoregion of central Goiás, Brazil. From January to June 2023 qualitative and quantitative variables were analyzed and results demonstrated low technological level and a small number of lactating cows, with mean monthly milk production of 1,917 liters, ranging from 1,576 to 2,131 liters. In most of the milk producing units, the milking equipment was of the piped type, with a ventilated milking parlour, coated only with concrete and with containments made of wood. Lastly, cows were fed with concentrated supplementation during milking. Conclusively, the milk produced had solids content within the standard established by current legislation.

Keywords: Dairy production, milk quality, farms in the mesoregion, central Goiás, Brazil

Introduction
Dairy production is practically present in all Brazilian municipalities and represents a secure source of income for families living in rural areas (Almeida & Bacha, 2021) [1]. Among the largest producers of bovine milk in the world, Brazil occupies the sixth position, with about 34.8 million tons currently (FAO, 2023) [2]. In the ranking of Brazilian states, the state of Goiás occupies the sixth position with about 2.5 billion liters per year of the total national generation (Embrapa, 2023) [3].

In Brazil, most milk production is developed by family farming and is concentrated in small properties with low technological level. Thus, Brazilian milk is susceptible to variations in quality tests because the proportion of producers involved is large (Menezes *et al.*, 2020) [4]. The search for the best quality of milk has become a constant for small producers, since, in addition to greater awareness of current farm managers, dairy products and the government are financially encouraging producers development (Antero *et al.*, 2020) [5].

Milk quality control includes tests that verify its composition, physical-chemical and microbiological characteristics (Han & Wang, 2023) [6]. The levels of fat, protein, mineral salts, lactose and vitamins are some of the parameters that define its composition, which can be influenced by genetics, management, nutrition, health, lactation period, stress situations of the animals, among other factors (Simeanu & Radu-Rusu, 2023) [7]. Presently, the Total Bacteria Count (TBC), also known as Standard Plate Count (SPC) is a test that indicates the level of hygiene in the milking process, as it counts the number of bacterial colonies present in a given milk sample. Likewise, the Somatic Cell Count (SCC) is an indicator of mastitis, as the disease may have a clinical or subclinical presentation and be of environmental or contagious origin, directly linked to the health of the animal's mammary gland (Oliveira *et al.*, 2017) [8].

In the Brazilian territory, Normative Instruction 76 [9] and Normative Instruction 77 [10] establish the minimum quality standards for bovine milk for human consumption. These legislations fix rules from milk collection to the milk industrialization, and among them are

the updated values for SPC and SCC related to refrigerated raw milk, both for individual producers and community tanks. Therefore, it is necessary to develop studies to identify the limiting factors of milk quality in the state of Goiás. Thus, this work aimed to relate aspects of dairy production, milk composition and milking structures from farms in the mesoregion of central Goiás, Brazil.

2. Material and Methods

This cross-sectional study was carried out from January to June 2023 in 20 farms producing and supplying bovine milk to a dairy industry in the municipality of São Luís de Montes Belos, Goiás, Brazil. This municipality is part of microregion 09, which is one of the eighteen microregions that form the mesoregion of central Goiás (Carvalho *et al.*, 2020) [11]. Farms were randomly selected and during follow-up, a checklist was completed with all information that addressed the type of milking, management, supply or not at the time of milking and productivity.

Data referring to the protein and fat contents, and levels of Somatic Cell Count (SCC) and Total Bacteria Count (TBC) were made available by the dairy industry. These data were part of the monthly program for milking quality. And, quality indicators analysis was carried out by evaluating the mean values from monitored months.

Quantitative variables were converted into indicators of predefined limits, with SCC of 500,000 SC per mL, SPC of 300,000 Colony Forming Units (CFU) per mL, minimum value of 3% for fat content and minimum of 2.9% for protein (Normative Instruction 77) [10], milk production per Milk Producing Units (MPU) of 1,500 liters/month, and productivity per cow/year of 2,500 liters.

Qualitative variables analyzed were: type and structures of milking (Closed or open circuit), lining of the pit in concrete or tile, containment system in metal or wood, ventilated or non-ventilated milking parlor, and concentrated supplementation provision during or after milking.

Results were expressed as mean and as absolute and relative frequencies. Windows version of the GraphPad Prism 5.01 software was applied to perform statistical analysis. And, one- or two-way ANOVA followed by Bonferroni post-tests with P values <0.05 were used.

3. Results and Discussion

The mean monthly milk production of the 20 farms was 1, 917 liters, ranging from 1,576 to 2,131 liters per MPU. A low technological level and a small number of lactating cows were observed, with low productivity per animal per year (Table 1).

Table 1: Milk production system from farms in the mesoregion of central Goiás, Brazil. Values expressed as absolute and relative frequencies. *p<0.05 all groups. One-way ANOVA and Bonferroni post-tests.

Variable*	Mean	Minimum	Maximum
Farms' production (liters/month)	1,917	1,576	2,131
Number of lactating cows	30	23	39
Productivity (liters/cow/year)	2,351	2,011	3,026
Fat in milk (%)	3.95	3.2	4.3
Protein in milk (%)	3.41	2.89	3.92
SCC[1] (thousand SC/mL)	436	131	721
SPC[2] (thousand CFU/mL)	281	51	301
[1]Somatic Cell Count; [2]Standard Plate Count			

The milk produced had solids content within the standard established by current legislation (Normative Instruction 77) [10]. However, even if the means of SCC and SPC (Table 1) are below from the recommended by legislation, an adequate microbiological quality of the milk and health of the animal's mammary gland was not fully confirmed, because, for the milk to be considered top quality, these variables values should be even lower (Middleton *et al.*, 2014) [12]. From the analysis of means, a positive relationship was also observed and within the Brazilian legislation standards for SCC and TBC. These results corroborate the analyzes by Lacerda *et al.* (2009) [13], Vairamuthu *et al.* (2010) [14] and Silva *et al.* (2018) [15], in which they indicate and reinforce that the same factors that compromise milk microbiological quality also affect the health of the animal's mammary gland.

There are reported discussions about the effect of SCC and TBC on protein and fat content of milk. High bacterial counts can lead to the degradation of milk protein components by proteolytic enzymes produced by microorganisms, and the high energy requirement for the metabolic activities of microorganisms can reduce the fat content in milk. There is a consensus among most authors that with an increase in TBC, protein and fat means tend to decrease (Andrade *et al.*, 2009; Bozo *et al.*, 2013 [17]; Oliveira *et al.*, 2017) [16, 17, 8]. Picinin (2003) [18] confirms that the higher the SCC, the lower the milk fat content; Lacerda *et al.* (2010) [19] observed that samples with lower SCC had a higher protein content. And there are still authors who report a positive correlation between SCC and percentage of fat (Souza *et al.*, 2010; Montanhini *et al.*, 2013) [20, 21]; SCC and protein (Sabedot *et al.*, 2011) [22]; and even TBC with protein percentage (Bueno *et al.*, 2008) [23].

Silva *et al.* (2018) [15] state that low SPC is the result of good hygiene practices in the production system, such as washing the milking cluster, cleaning the milk cooler, proper maintenance of the milking machine, quality water and adequate milk cooling. Lacerda *et al.* (2009) [13] affirm that the water used during the cleaning procedure of equipment, facilities and milking processes may be another factor compromising milk quality.

Table 2 describes that in most of the MPUs, the milking equipment was of the piped type, with a ventilated milking parlour, coated only with concrete and with containments made of wood. Finally, cows were fed with concentrated supplementation during milking.

Table 2: Milk production structure from farms in the mesoregion of central Goiás, Brazil. Values expressed as absolute and relative frequencies. *p<0.05 all groups. One-way and two-way ANOVA and Bonferroni post-tests.

Variable*	Class	*n*	%
Milking equipment	closed circuit	6	30
	open circuit	14	70
Milking parlor aeration	ventilated	17	85
	non-ventilated	3	15
Containment system	wood	15	75
	metal	5	25
Pit lining	tile	2	10
	concrete	18	90
Feeding time	after milking	7	35
	during milking	13	65
Farm production (liters per month)	≤ 1.50	12	60
	≥ 1.500	8	40
Productivity (liters/cow/year)	≤ 2.500	7	35
	≥ 2.500	13	65
SCC[1] (thousand SC/mL^{-1})	≤ 500	15	75
	≤ 500	5	25
TBC[2] (thousand CFU/mL^{-1})	≤ 300	16	80
	≤ 300	4	20
[1]Somatic Cell Count; [2]Total Bacteria Count			

Milking structures are among the factors that affect animal welfare (Rohleder *et al.*, 2022) [24]. Inadequate, poorly ventilated, poorly sanitized facilities and uneven floors can cause pain, discomfort and stress in animals (Collier *et al.*, 2019) [25]. Stress can directly implicate in a herd's health, such as loss of appetite and low immunity, making it more susceptible to diseases (Roth, 2017) [26]. In this research, it was verified that technologies and physical structures are not a guarantee of a better quality of milk, but when correctly used can assist to improve indicators.

4. Conclusion
There was a positive relationship between SCC and SPC, being those antagonists to the percentages of fat and protein. The productivity per animal and farms' milk production had a positive relationship, not being influenced by SCC and SPC, or even by the fat and protein contents.

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6. Declaration of interest statement
Authors report no declarations of interest.

Conflict of interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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