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Milk quality in high production systems during dry and rainy seasons according to normative instruction N° 62

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This study aimed to evaluate the milk quality of crossbred cows from five production systems according to the quality parameters required by Normative Instruction No. 62 (NI 62). Five different production systems were used, with different environmental and sanitary conditions, and with animals from different breeds in two seasons: dry and rainy. Three individual milk samples were collected from animals in the five production systems during the dry season; the same number of samples was collected during the rainy season. The samples were evaluated in the Milk Quality Laboratory of the Federal University of Goiás using analytical principles based on infrared differential absorption of milk components. The data were analyzed with a 2 × 5 factorial system in which factor 'A' includes the seasons and factor 'B' includes the five different production systems. The values of fat, protein, lactose, nonfat solids (NFS) and somatic cell count (SCC) were analyzed. Throughout the experiment, the chemical composition of milk was in accordance with NI 62; however, in relation to SCC, System 2 did not produce milk with optimal quality parameters and did not follow the criteria established by law. The analyzed milk had higher protein content of 3.32%, NFS of 8.89% and SCCs of 492,180 SC/mL during the rainy season compared to the dry season. Higher SCCs were also observed with increasing concentrations of fat and protein in the milk. Lactose and NFS values were found in lower concentrations with increasing SCCs due to epithelial damage present in animals with high SCCs. The systems differ among each other in some factors due to the particularity of each system. It was concluded that the milk components are in agreement with those required by NI 62, however all systems produced milk with higher SCC levels during the rainy season.

Key words: Chemical composition, somatic cell count, season, individual milk samples, quality.

INTRODUCTION

Currently, Brazil is the fifth largest milk producer in the world, behind the United States, India, China and Russia, producing approximately 31 billion L of milk in 2011 (USDA, 2012). The Southeast region dominates milk production in Brazil, generating 36% of the national production, followed by the South (31%) and Midwest

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(14%) regions, with the state of Goiás as the most important in the Midwest (IBGE, 2010). In 2011 alone in the state of Goiás, 2,615,611 dairy cows were milked, producing 3,482,041 L of milk, making this state the 4th largest milk producer in the country, behind only Minas Gerais, Rio Grande do Sul and Paraná (IBGE, 2011). Consumers demand that all food items, including dairy products, are safe, nutritious and have a pleasant taste and texture. Thus, milk quality is one of the most discussed topics among national livestock producers due to the large share that this product has in the socio-economic sector of the country. High-quality milk is produced by healthy and well-fed cows; the nutritional qualities of the milk are preserved throughout the production stages, and the milk poses no risk to human health (Cani and Frangilo, 2008). Somatic cell count (SCC) in milk is used as a measure of mammary gland health and milk quality. The presence of high SCCs affects the shelf life of milk products and causes growth inhibition of starter cultures for dairy production, causing large losses in the dairy industry (Tronco, 2008). The use of SCC values as a tool for monitoring mastitis and evaluating milk quality began in the late 1970s in the USA, where the first legal limit was 1,500,000 somatic cells (SC)/mL (Dohoo and Leslie, 1991). Starting in 1992, the EU countries adopted the value of 400,000 SC/mL as the maximum legal limit for SCC, while in Canada and the U.S., the limits are now 500,000 and 750,000 CS/mL, respectively (Schukken et al., 2003).

Since 1997, organizations such as the National Mastitis Council (NMC) have proposed to reduce this limit to 400,000 SC/mL, without success (Santos, 2006). Even with a limit of 750,000 SC/mL, the mean SCC value of North American cattle in 2010 was 228,000 SC/mL (97% of cattle under SCC control), and only two states have means above 400,000 SC/mL (Santos, 2012). To promote milk quality, since 2002, the Ministry of Agriculture, Livestock and Supply (Ministério da Agricultura, Pecuária e Abastecimento - MAPA) has made improvements of milk quality with Normative Instruction No. 51 and in 2011 has established Normative Instruction No. 62 (IN 62), which provides acceptable SCC and total bacterial count (TBC) limits of 600,000 SC/mL and 600,000 colony forming units (CFU)/mL, respectively, starting since January 2012 until July this year 2014. For now, it has established value of 500,000 SC/mL and 300,000 CFU/mL for SCC and TBC, respectively (Brasil, 2002; Brasil, 2011).

Final milk quality is the result of the interaction of multiple factors related to genetics, nutrition, management, health, market and environmental conditions; not all of these factors can be controlled experimentally. With this prerogative, this study aimed to evaluate the quality parameters established by the current Normative Instruction among different dairy farm production systems, thus characterizing the obstacles to obtaining high-quality milk.

MATERIALS AND METHODS

The study was conducted during the dry and rainy seasons, from February to September 2012, in five production systems in the Southwest region of Goiás, located in the Brazilian Midwest. Individual samples were collected from lactating animals, with the aid of individual mechanical milking machines.

Collection of milk samples

All milking systems started with the washing of the udder with water as needed, followed by removal of the first three streams of milk into a dark-bottom container to observe the presence of clumps characteristic of clinical mastitis. With the aid of a back flushing device, the udder was immersed in pre-dipping solution for disinfection. Then, the udder was dried with paper towels, and the teat cups were attached for milking. Through a meter coupled to each milking claw, the milk mixture was performed in the collector itself. Then, an individual milk sample was taken from the lactating cows and stored in 40 mL flasks containing Bronopol®. At the end of the milking, post-dipping was performed, in which the udders were immersed in disinfectant solution. All dairy production systems had shading to prevent heat stress. The animals were supple-mented with mineral salts, and untreated water was available in abundance from streams, wells and tanks located in the same area.

Particularities of the dairy production systems

System 1

Animals of Holstein, Jersey, Girolando, Brown Swiss and cross: Two daily milkings at 5:00 am and 5:00 pm. Facilities: Farm with shading and well wooded. Wait corral paved and milking parlor with 10 milking claws under a tile-lined pit. The animals were kept on pasture and were supplemented with food during milking according to production. The pre and post-dipping solutions used consisted of 10% iodine.

System 2

Holstein cows: Three daily milkings at 6:00 am, 2:00 pm and 10:00 pm. Facilities: Sombrite and the water used were untreated. Corral waiting paved the side of the 10 sets of liners parlor under a lined pit tiles and narrow corridors. The animals were kept in paddocks and confinement. The animals were treated with corn silage, mineral salt and water *ad libitum* and the concentrate was prepared for each lot according to the production. In most animals cytokine was used. Pre-dipping iodine base 2% glycerin and post-dipping Filmadine®.

System 3

Animal genetics high Holstein: Three daily milking at 5:00 am, 12:00 pm and 7:00 pm. Facilities: Sombrite and water used were untreated. Corral waiting rubberized next to the milking parlor six semi-automatic liners sets under a lined pit tiled. The animals were kept in paddocks and confined receiving corn silage, mineral salt and water *ad libitum* and concentrate according to production. As a pre-dipping towels soaked in Dermisan® and post-dipping Filmadine®.

System 4

Holstein-Brown Swiss crossbred animals: Two daily milkings first at

Table 1. Changes in the levels of fat, protein, lactose, NFS and SCC in milk from different dairy production systems.

Production system	Fat (%)	Protein (%)	Lactose (%)	NFS (%)	SCC(thousand SC/mL)
1	3.59[a]	3.32[ab]	4.59[ab]	8.88[a]	349[c]
2	3.57[a]	3.37[a]	4.49[d]	8.83[a]	812[a]
3	3.43[b]	3.26[b]	4.55[c]	8.76[b]	524[b]
4	3.40[b]	3.29[b]	4.63[a]	8.88[a]	331[c]
5	3.68[a]	3.28[b]	4.56[bc]	8.79[ab]	557[b]
CV (%)	26.27	11.77	6.19	5.22	22.94

Means followed by the same letter in the same row are not significantly different (p>0.05) according to Tukey's test. CV = coefficient of variation. SCC = somatic cell count expressed in thousand SC/mL.

4:00 am and the second at 4:00 pm. Facilities: Sombrite and untreated water. Wait corral paved side of the milking parlor with 12 sets of liners under a lined pit tiled. The animals were kept on pasture in rotational grazing and getting cane chopped sugar, mineral salt and water *ad libitum*. As a pre-dipping and post-dipping was used at 0.5% iodine.

System 5

Crossbred Dutch, Jersey and Gir: Two daily milkings at 5:30 am and 4:30 pm. Animals on pasture and supplemented with corn silage and concentrate the will. The water will in drinking fountains, untreated. Barnyard paved waiting beside the milking parlor of scale crappie with 6 sets of liners, closed circuit. The parlor was unpaved and in poor condition, had no moat and milkers let down in stools. Management controlled the pre and post-dipping precariously with the basis of sodium hypochlorite.

Sample routing and milk analysis

Milk samples were collected once a week for three consecutive weeks, and only from first milking of the day, both during the dry and the rainy seasons. The samples were homogenized for complete dissolution of the preservative, packed in isothermal boxes containing ice and sent to the Milk Quality Laboratory of the Food Research Center (Laboratório de Qualidade do Leite do Centro de Pesquisa em Alimentos – LQL/CPA), School of Veterinary and Animal Sciences, Federal University of Goiás (Universidade Federal de Goiás - UFG), for electronic analysis and determination of milk components.

Chemical composition

The fat, protein, lactose, TS and NFS contents were determined by analytical principle, based on infrared differential absorption of milk components, using the MilkoScan 4000 (Foss Electric A/S. Hillderod, Denmark). The samples were previously heated in a water bath at 40°C for 15 min to dissolve the fat, and the results are expressed as percentages (%).

Somatic cell count

SCCs were performed using a Fossomatic 5000 Basic (Foss Electric A/S. Hillerod, Denmark), which is based on flow cytometry. A sample aliquot is automatically pipetted into the device and mixed with the reagents. The membranes of the somatic cells rupture, allowing the DNA to be stained with ethidium bromide. The device features a halogen lamp that emits a blue light that causes the emission of red light pulses when it hits stained DNA. These pulses were amplified and counted with a photo-multiplier, and the result is expressed in SC/mL.

Statistical analysis

The data were evaluated in a 2 × 5 factorial arrangement, with factor A including two seasons, dry and rainy, and factor B consisting of five different production systems. The following variables were analyzed: fat, protein, lactose, NFS and SCC. The study was conducted by dividing the different production systems: System 1 (107 animals), System 2 (170 animals), System 3 (125 animals), System 4 (150 animals) and System 5 (90 animals). The systems were evaluated in two seasons, dry and rainy, with three replicates in each season, resulting in a total of 3000 samples and 10 treatments, five for each season. There was a decrease in the number of samples due to losses and/or variation in the number of lactating animals in the different seasons. The SCC values were transformed to log base 10 and subsequently analyzed. Tukey's test at a 5% significance level was used for analysis with SISVAR software (Ferreira, 2011). Linear regression analysis was used to assess the effects of the dependent variables (fat, protein, lactose and NFS) as functions of SCC intervals – 1 (up to 200,000 SC/mL), 2 (201,000 to 400,000 SC/mL), 3 (401,000 to 600,000 SC/mL) and 4 (601,000 above SC/mL). Differences were considered significant at $p < 0.05$ for a confidence interval of 95%.

RESULTS AND DISCUSSION

The mean results of the variation of chemical composition and SCs in the milk from different production systems are shown in Table 1. According to Table 1, there was no difference between the fat contents of Systems 1, 2 and 5, with means of 3.59, 3.57 and 3.68%, respectively. These systems were significantly different compared to Systems 3 and 4, which had means of 3.43 and 3.40%, respectively, but did not differ from each other. This difference can be attributed to the high production levels of Systems 3 and 4; by the dilution factor, these systems had decreased fat contents. The fat values of all dairy systems are above the limit suggested by the NI 62/2011, which is at least 3.0% (Brazil, 2011). In the evaluation of the composition of milk from Holstein cows kept in elephant grass pasture, Voltolini et al. (2010) reported mean fat contents of 3.98%. The observed milk production was lower (16.72 kg) than the averages of 28 and 26.66 kg from Sys-tems 3 and 4, respectively, confirming

Table 2. Changes in the contents of fat, protein, lactose, NFS and SCC in different dairy production systems during the dry and rainy seasons.

Production Systems	Fat (%)		Protein (%)		Lactose (%)		NFS (%)		SCC(thousand SC/mL)	
	Rain	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
1	3.54[Bbc]	3.71[Aa]	3.31[Aa]	3.32[Aab]	4.57[Bb]	4.63[Aa]	8.88[Aab]	8.90[Aa]	380[Ac]	275[Bc]
2	3.51[Abc]	3.62[Aab]	3.36[Aa]	3.39[Aa]	4.54[Ab]	4.46[Bb]	8.90[Aab]	8.79[Bb]	1084[Aa]	630[Ba]
3	3.31[Bc]	3.50[Ab]	3.20[Bb]	3.29[Ab]	4.45[Bc]	4.60[Aa]	8.60[Bc]	8.85[Aab]	688[Ab]	433[Bb]
4	3.56[Ab]	3.21[Bc]	3.35[Aa]	3.22[Bc]	4.66[Aa]	4.59[Ba]	8.99[Aa]	8.76[Bb]	370[Ac]	284[Bc]
5	3.95[Aa]	3.60[Aab]	3.39[Aa]	3.26[Bbc]	4.41[Bc]	4.60[Aa]	8.79[Bb]	8.83[Aab]	521[Ab]	567[Aa]
Overall mean	3.53[a]	3.49[A]	3.32[b]	3.29[B]	4.58[A]	4.58[A]	8.89[A]	8.82[B]	492.18[A]	412.19[B]
CV (%)	26.27		11.77		6.19		5.22		22.94	

Uppercase letters differ in the rows; lowercase letters differ in the columns. Means followed by the same letter in the same row or column are not significantly different (p>0.05) according to Tukey's test. CV = coefficient of variation. SCC = somatic cell count expressed in thousand SC/mL. Values are expressed in %.

the dilution factor. The average protein content produced by the five dairy systems during the experimental period was higher than that required by law, which is at least 2.9%. System 2 (3.37%) was superior to Systems 3 (3.26%), 4 (3.29%) and 5 (3.28%), and System 1 (3.32%) did not differ from the other dairy systems.

According to Dürr (2002), the changes in the protein content of milk are less significant, and although they influence total production, they yield little variation in the milk. Thus, among the different quality parameters, milk protein is one of the most important, especially for the industry, due to the relationship with the industrial yield. The average lactose measured in the different systems exhibited wide variation, and although System 4 (4.63%) did not differ from System 1 (4.59%), it was higher than other systems. System 5 (4.56%) did not differ from Systems 1 and 3 (4.55%) and was higher than System 2 (4.49%), which had the lowest average lactose composition. The dairy systems with low lactose content had higher SCCs due to changes in lactose concentration as a result of the lactose being transferred from the milk to the blood.

Reis (2010) observed that, in the samples with high SCCs, milk lactose content decreased due to the damage caused in the glandular epithelium. Tissue injury caused by mastitis reduces the capacity for lactose synthesis by the glandular epithelium, which, due to the central role of lactose as an osmotic regulator of milk volume of milk, affects the amount of milk produced (Harmon, 1994). In regards to NFS, there was little variation among the production systems. Only System 3 had a lower NFS value than the other systems and may be characterized by the low lactose due to the high SCC in this system. System 2 had the highest SCC (812,000 SC/mL). Systems 3 and 5 were not significantly different from each other, averaging 524,000 and 557,000 SC/mL, respectively. Systems 1 and 4 were not significantly different from each other but had the lowest mean SCCs: 349,000 and 331,000 SC/mL, respectively. These results highlight the importance of hygiene and milking management, as System 2 had good facilities and qualified workers; however, much of the herd suffered from some kind of hoof disease or pododermatitis, which may increase the amount of defense cells in the organism, thereby increasing the SCC. Although, System 5 had simpler management and facilities and had mixed-breed animals, it had SCC values similar to System 3, which had highly technological facilities and animals with high genetic merit. Therefore, facilities and technology alone do not characterize the quality of the milk produced. The systems with smaller SCC values, Systems 1 and 4, had the best milking management and animal health care, good facilities and effective workers, given that good hygiene and milking management are ideal for maintaining mammary gland health and milk quality.

According to Coentrão et al. (2008), appropriate procedures during milking and careful use and maintenance of milking equipment can decrease the chance of animals presenting SCCs above 200,000 SC/mL up to 2.51 fold. Pre-milking and post-milking procedures are essential in the control and prevention of mastitis and deserve specific training and dedication (Souza et al., 2005). Table 2 shows the results of the factorial analysis of fat, protein, lactose, NFS and SCC of different production systems during the dry and rainy seasons. During the rainy season, System 5 produced milk with higher fat content (3.95%) compared to the other systems, which differ among themselves, with fat levels ranging from 3.51 to 3.56%. These results reflect production that is typical of the breed, as crossbreed Jersey animals, found in System 5, tend to produce higher fat content compared to pure Holstein animals. According to Gonçalves et al. (2005), Holstein cows are known to produce milk with low fat content.

Botaro et al. (2011) observed that the highest fat concentrations were obtained from Jersey animals (3.97%) compared to Holstein (3.54%) and Girolando (3.45%) cows. During the dry season, in terms of fat content, Systems 1 (3.71%), 2 (3.62%) and 5 (3.60%) did not differ among themselves and obtained the highest averages. Systems 2, 3 (3.50%) and 5 did not differ significantly among themselves and were superior to System 4 (3.21%), which had a lower average fat content. System 4 used sugarcane, which has a lower amount of digestible fiber, in place of corn silage, whose dry fiber is responsible for the presence of fat in milk.

According to Oliveira et al. (2007), the ratio of forage or fibrous material available to the lactating cows as a source of roughage is associated with acetate production, which is the primary precursor in the synthesis of milk fat. In relation to the dry and rainy seasons, the levels of fat measured in Systems 2 and 5 did not differ. In System 4, the fat content was higher during the rainy season, a period in which pasture intake is abundant. Fresh pasture has high levels of long-chain polyunsaturated fatty acids, justifying the increase in fat content and the fatty acid profiles of milk observed during the different seasons (Heck et al., 2009). This was observed in System 4, in which the animals were kept in rotating pasture, with strict grass quality control and maintenance during the rainy season. In Systems 1 and 3, the opposite occurred: fat contents were higher in the dry season compared to the rainy season. This is because during the dry season, the animals were kept in confinement, fed corn silage concentrate and for some animals in System 1, sugarcane instead of silage. During this season, there was decreased milk production, causing the fat to become more concentrated.

In the rainy season, the protein content of all systems was within the limit suggested by NI 62, which is at least 2.9% (Brazil, 2011). Only System 3 (3.20%) was significantly lower than the other systems because feeding in this system was constant throughout the year, with no concentrate correction. The largest difference between the systems was observed during the dry season, with Systems 4 (3.29%) and 5 (3.28%) obtaining the lowest average protein levels. The magnitude of changes in the protein contents of milk due to the manipulation of the cows' diets is well below the changes that the diets cause on fat content (Sutton, 1989). The increase in energy concentrate in the diet stimulates the production of propionic acid by rumen microorganisms, increasing energy availability and favoring microbial rumen production, resulting in increased availability of amino acids for absorption in the small intestine and serving as a substrate for the synthesis of milk protein. However, protein supplementation gives less-consistent responses in the production of milk protein (Hongerholt and Muller, 1998).

Mammary gland infection causes an increase in pH and changes in the permeability of the membrane that separates blood from milk, leading to an influx of albumin and immunoglobulins to the interior of the gland and increasing the concentration of total milk protein (Cunha et al., 2008). Systems 1 and 2 did not differ between each other in terms of protein content during both the dry and rainy seasons. The mean protein levels in Systems 4 and 5 were statistically higher during the rainy season compared to the dry. Due to the higher availability and better quality of food during the rainy season compared to the dry, the systems maintain their animals on pasture, providing concentrate throughout the year and supplementing with silage, sugarcane and concentrate in the dry season. These observations were not noted in System 3, in which the animals were kept in confinement throughout the year. Because there is a decrease in milk production during the dry season, the concentration of the milk components increases. In terms of lactose content during the rainy season, System 4 (4.66%) had the highest average, while Systems 1 (4.57%) and 2 (4.54%) did not differ between each other and were higher than Systems 3 (4.45%) and 5 (4.41%), which had the lowest means and also did not differ between each other.

During the dry season, the mean lactose ranged from 4.63 to 4.59%; only System 2 was significantly lower than the others, with a mean of 4.46%. Greater milk production stability among the systems was observed during the dry season. Lactose is the main osmotically active milk component, and there is consensus in the literature regarding the fact that lactose is the milk component that is the least affected by diet. Lactose is considered the "pacemaker" of milk production, that is, the higher the amount of propionic acid available for the synthesis of lactose in the udder, the higher the amount of milk secreted (Milani, 2011). This is because lactose and potassium in cow's milk (with a healthy udder) maintain the equilibrium between milk and blood through the removal of water from the extra- and intracellular fluids (Mühlbach et al., 2000). Studies have shown that there may be a decrease in lactose content in cases of diseases such as mastitis (Machado et al., 2000; González et al., 2006) and situations of energy malnutrition (Bueno et al., 2005), as glucose availability is a limiting factor for milk synthesis.

During the rainy season, the NFS remained proportional compared to the milk components fat, protein and lactose, with the lowest content found in System 3(8.60%) due to the genetic purity of Holstein cows in this system, which tend to produce lower concentrations of milk solids. During the dry season, there was little

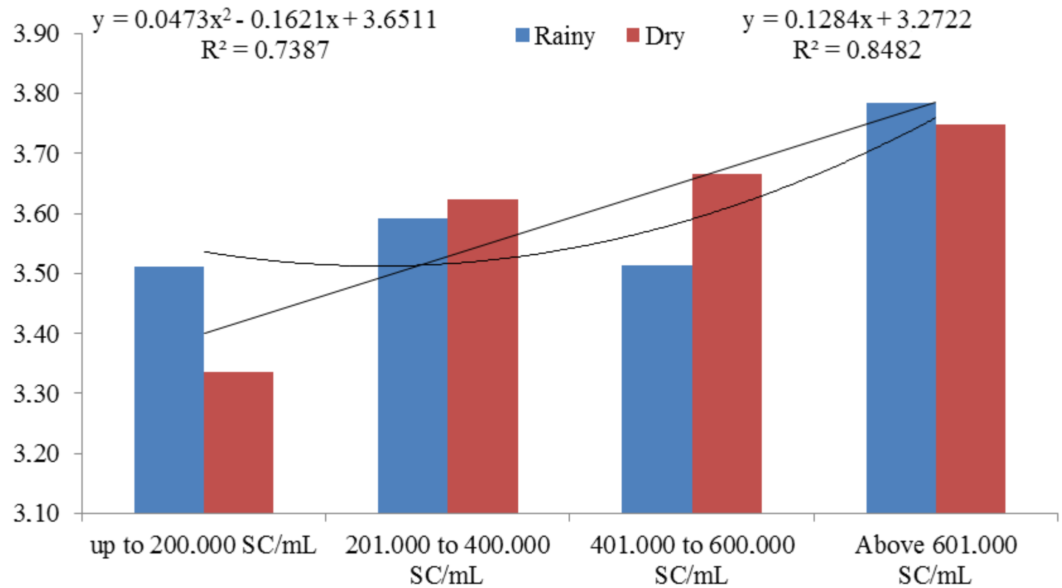

Figure 1. Fat regression in relation to SCC levels 1 to 4 during the dry and rainy seasons.

variation in NFS among the systems; NFS content was proportional to lactose content stability during the dry season. According to Reis et al. (2007), NFS was positively correlated with protein and lactose contents. Zanela et al. (2006) reported that high NFS levels are related to the higher percentages of lactose and casein, which is consistent with the data found in the present study in the different dairy systems. When comparing the rainy and dry seasons, only System 1 had no change in the NFS content. In Systems 2 and 4, the NFS contents during the rainy season were higher than during the dry season; the same occurred with the protein and lactose contents. In Systems 3 and 5, the NFS levels were higher during the dry season, which is consistent with the protein and lactose contents found in these dairy systems. In regards to SCC, System 2 had the highest average during the rainy season, 1,084,000 SC/mL, likely due to high incidence of pododermatitis in the dairy herd, which increased the supply of defense cells in the body, increasing milk SCCs.

The system in question, according to NI 62 from 2011, did not pass the quality standards set by law and should not be marketed (Brazil, 2011). Systems 3 and 5 did not differ statistically between each other, resulting in mean values of 688,000 and 521,000 SC/mL, respectively, during the rainy season. Systems 1 and 4 had the lowest mean SCCs and did not differ between each other, yielding values of 380,000 and 370,000 SC/mL, respectively. These systems have the ideal milking management, with the use of pre- and post-dipping in the correct way, efficient drying of the udder and waiting during the milking until the milk is fully descended; in addition, these systems have adequate facilities for the performance of good milking practices. During the rainy season, Systems 1, 4 and 5 produced milk in accordance with the current law; however, only Systems 1 and 4 met NI 62 in regards to SCCs for the year 2014, which will reduce the maximum SCC from 600,000 to 500,000 SC/mL. A similar phenomenon occurred during the dry season, with much lower averages. The systems with the highest SCCs were System 2 (630,000 SC/mL), which did not produce milk in accordance with NI 62, and System 5 (567,000 SC/mL) during the dry season. System 3 had a mean of 433,000 SC/mL. Systems 1 and 4 had the lowest SCC means, with 275,000 and 284,000 SC/mL, respectively, staying within the limits recommended by the legislation.

According to Almaw et al. (2008), management practices can affect the prevalence of intramammary infection because mastitis is a complex disease that results from multiple predisposing factors. When comparing SCCs from the different seasons, the rainy season produced the highest SCC means. Only System 5 showed no significant difference between the seasons. Magalhães et al. (2006), when studying seasonal effect on SCC, observed that in the winter, the SCC was lower than in the summer because during months of high temperature and humidity, the cows are more susceptible to mastitis due to increased heat stress and greater exposure to pathogens. Gonzáles et al. (2006) observed that the months of the year affected the chemical composition of milk and the occurrence of mastitis, which was related to variations in the availability and quality of feed and to the favorable climatic conditions for the microorganisms. Excessive precipitation was related to higher rates of mastitis, and the SCC met the parameters required by NI 62 only in Systems 1, 4 and 5. During the dry season, Systems 1, 3, 4 and 5 were in accordance

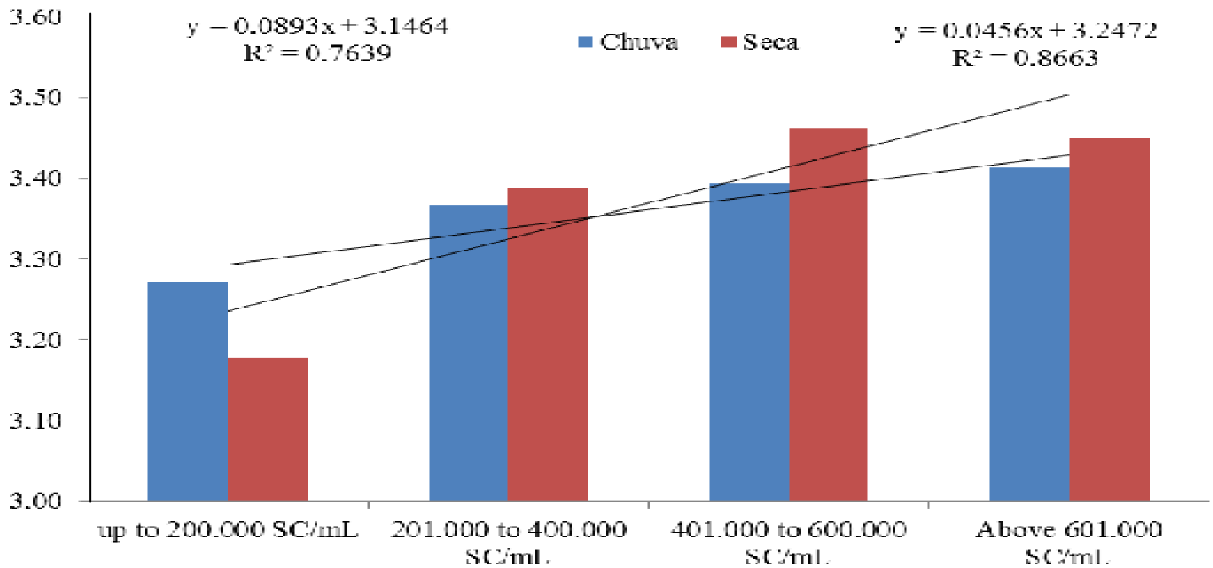

Figure 2. Protein regression in relation to SCC levels 1 to 4 during the dry and rainy seasons.

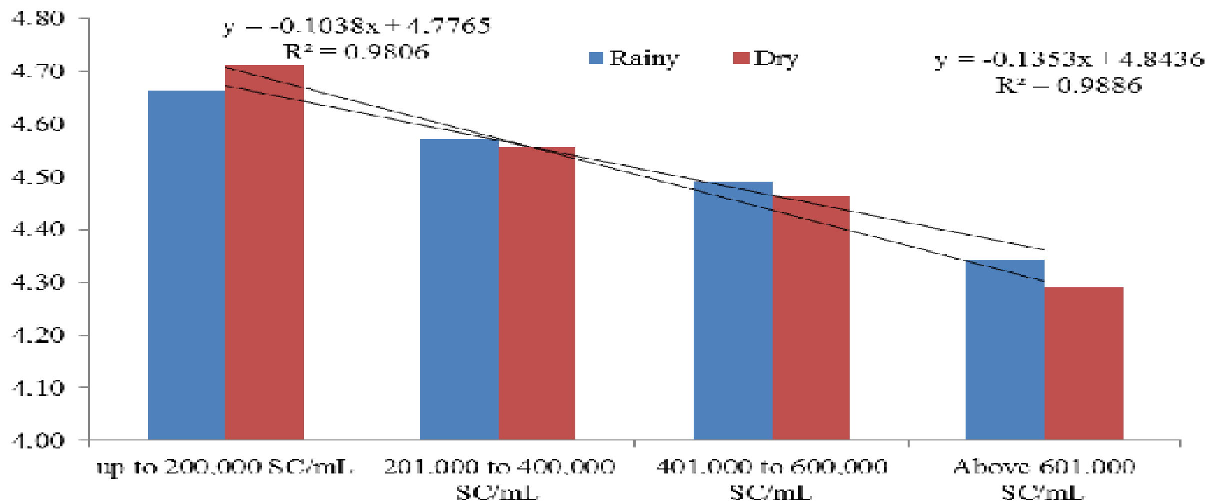

Figure 3. Lactose regression in relation to SCC levels 1 to 4 during the dry and rainy seasons.

with the instruction. The results of the fat contents for the different SCC levels during the rainy and dry seasons are illustrated in Figure 1, represented by increasing regression; as the SCC increased, fat content also increased during both seasons.

Santos and Fonseca (2007) reported that mastitis reduces the amount of milk produced by the animal and causes a reduction in the concentration of milk components (fat, casein and lactose). Bansal et al. (2005) disagreed with those findings because they observed higher fat concentrations in milk from cows with mastitis, demonstrating that when the milk production is reduced more intensely than the synthesis of fat, the fat can become concentrated in milk and is therefore found in higher levels. Ventura et al. (2006), evaluating the SCC and its effects on milk constituents, found that an increase in SCC values leads to an increase in fat percentage. Figure 2 shows protein levels compared to SCC levels during the dry and rainy seasons, represented by an increasing linear regression curve. As the level of SCC increased, so did the milk protein concentration in the systems studied, during both the dry and the rainy seasons. Milk casein undergoes significant reduction when the SCC increases due to the actions of leukocyte and blood proteases (Harmon, 1994).

Cunha et al. (2008), analyzing Holstein cows, observed a positive correlation between SCC and the percentages of fat and protein in the milk. According to the linear

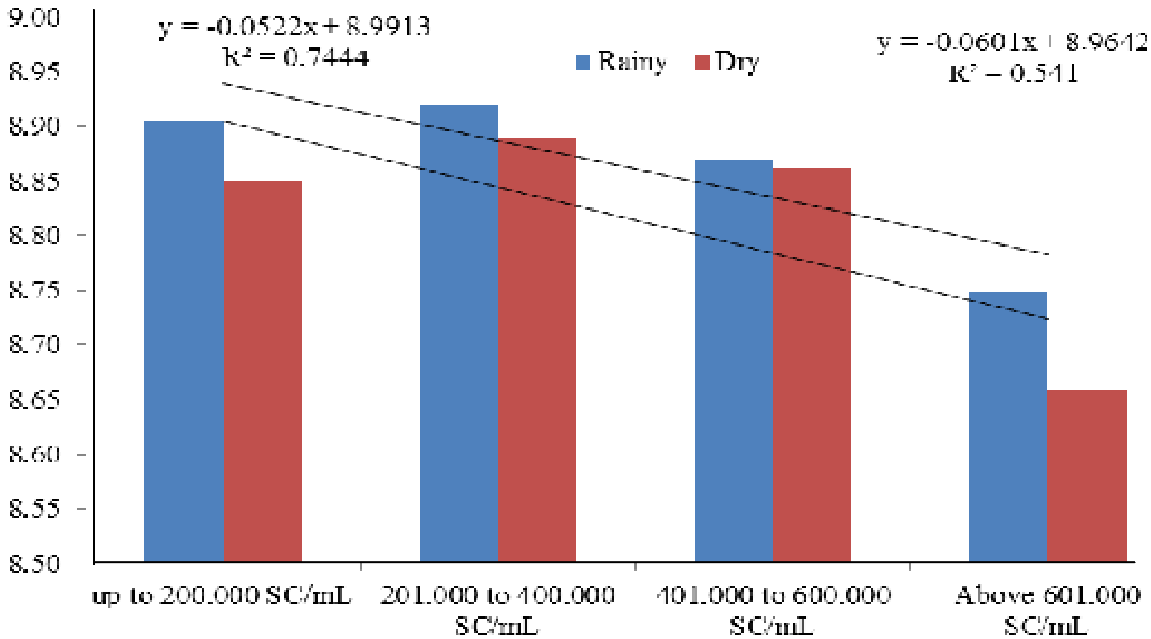

Figure 4. NFS regression in relation to SCC levels 1 to 4 during the dry and rainy seasons.

regression shown in Figure 3, the higher the SCC, the lower the lactose content in the milk. Prada et al. (2000) analyzed 1,361 milk samples comparing SCC in relation to lactose, observing a positive correlation between increasing SCC and decreasing lactose content of the milk. Bueno et al. (2005) observed that the increase in SCC is related to the reduction of lactose and total solids concentrations. A decreasing linear regression was observed for the NFS in relation to the SCC, characterized by the sharp slope observed for lactose with increasing SCC (Figure 4). The same was observed by Rangel et al. (2009), analyzing the milk of 12 cows during the period of August to October 2004, concluding that the increase in SCC causes decreases in lactose and NFS pe rcentages. The milk components of all systems under study were in accordance with NI 62 for both the dry and the rainy seasons. For the SCC values, System 2 was above the limit required by law and should not be marketed.

The SCC values are affected by the degree of mastitis in the herd, the disease agent, the lactation stage, the stage of parturition, season, milking hygiene, appropriate milking environment and hygiene management. The milk components did not change dramatically and stayed within the required levels recommended by the legislation.

Conclusion

When observing the systems, it was noted that the milk components are in agreement with those required by NI 62. For the SCC values, System 2 does not fit the required parameters, and the hygiene, management and health need to improve for the milk quality to improve. During the dry and the rainy seasons, wider variation was observed among the systems. The chemical composition remained in accordance with the limits prescribed by law. The SCC of System 2 did not meet the requirements of NI 62, which limit the maximum count to 600,000 SC/mL until the year 2014 for this region, during both the dry and the rainy seasons; additionally, during the rainy season, System 3 did not meet the legislation standards. All systems produced milk with higher SCC levels during the rainy season due to numerous factors related to the particularities of the region and the health management of the animals. As the SCCs increased, the levels of fat and protein also increased. Reductions in the levels of lactose and NFS were observed.

Conflict of interests

The author(s) did not declare any conflict of interest.

Abbreviations: NFS, Nonfat solids; **SCC,** somatic cell count; **NMC,** National Mastitis Council; **TBC,** total bacterial count.

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