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Effect of the somatic cell count on physicochemical components of milk from crossbred cows

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The aim of the present work was to evaluate the effect of somatic cell count on the composition of milk in individual samples from crossbred cows at the Rio Verde municipality. Data from 2,730 individual samples of milk from crossbred cows were used. The samples were collected between February and April 2012 and analyzed at the Milk Quality Laboratory (Laboratório de Qualidade do Leite) in the Food Research Center (Centro de PesquisaemAlimentos) of the School of Veterinary Medicine and Animal Science of the Federal University of Goiás (Escola de Veterinária e Zootecnia da Universidade Federal de Goiás). Protein, fat, lactose, casein, urea, defatted dry extract and somatic cell counts (SCC) were analyzed. A completely randomized experimental design was used. An analysis of variance was performed, and individual means were compared using Tukey's test ($p<0.05$). The urea content did not vary with increasing SCC. The lactose levels decreased with increasing SCC. The defatted dry extract was minimally influenced by increasing SCC.

Key words: SCC, percent composition, milk quality, casein, urea.

INTRODUCTION

Mastitis has an extremely detrimental effect on the composition and physicochemical characteristics of milk, which is accompanied by an increase in the somatic cell counts (SCC) in milk. Andrade et al. (2007) reported that mastitis is one of the main causes of decreased milk quality and quantitative losses in milk production, and it is the disease causing the greatest loss for dairy farming, both in Brazil and worldwide. Mastitis is responsible for increasing the levels of somatic cells, in addition to causing lesions in the milk-producing epithelial cells and increasing the vascular permeability, which results in a greater passage of substances from the blood to the milk, such as sodium, chlorine, immunoglobulins, and other serum proteins (Kitchen, 1981). From the point of view of the industry, a high SCC results in problems during milk processing and in decreased yields as a consequence of the low casein, fat, and lactose contents, which result in products of low quality and stability (Brito, 1999b).

Protein has a high nutritional relevance and economic importance in payment-for-quality programs, mostly because casein is the main component in the manufacture of dairy products (Emmons et al., 2003).

Urea nitrogen has been used in herd nutrition assessments because it is directly correlated to the urea levels in plasma and blood (Depeters and Ferguson, 1992). According to Chase (1994), dairy cows secrete an average of 25 to 35% of the nitrogen they consume into their milk. Almost all remaining nitrogen is excreted in urine and feces. Using the urea nitrogen content of milk to adjust the contents of feed protein and energy reduces feeding costs, and results in increased animal performance (Nelson, 1995). Increase in protein nitrogen concentrations in milk result in decreased industrial yield in cheese production because the serum proteins and casein are replaced by non-protein nitrogen, which increases the time for cheese curdling (Ferreira et al., 2006). Hojman et al. (2004) reported that the urea nitrogen concentration of milk is lower in samples with a high SCC.

Most of the dairy industries have based milk payments on quality criteria, with the aim of encouraging producers to seek to improve the milk quality. This practice increases the industry's production yield, with the producer receiving a bonus for the supplied product, and a better-quality product reaches the consumer.

In Brazil, as in other countries, the highest valued milk constituents in terms of the payment-for-quality programs are fat and protein because they are related to a higher industrial yield. The SSC in milk is a diagnostic method of subclinical mastitis, and it is internationally accepted as the standard method to determine the quality of raw milk (Ribas, 1999). Magalhães et al. (2006) reported that a high SCC results in decreased economic profit for the producer due to reduced production, higher expenses for medical drugs, and penalties applied by dairies.

The goal of the present study was to evaluate the influence of the SSC on the chemical components of milk originating from individual samples,which were collected from crossbred cows in the Rio Verde municipality in the state of Goiás (GO).

MATERIALS AND METHODS

Data from 2,730 individual samples of milk from Holstein-Zebu crossbred cows were used. The samples were collected in the Rio Verde municipality, in the state of Goiás, between February and April, 2012 and were analyzed at the Milk Quality Laboratory (Laboratório de Qualidade do Leite- LQL) in the Food Research Center (Centro de Pesquisaem Alimentos - CPA) of the School of Veterinary Medicine and Animal Science of the Federal University of Goiás (Escola de Veterinária e Zootecnia da Universidade Federal de Goiás- EVZ/UFG). Protein, fat, lactose, casein, urea, defatted dry extract (DDE), and SCC were analyzed.

The samples were collected following the completion of milking with individual measurers via a valve at the bottom that, prior to sample collection, was positioned in the agitation mode for approximately five seconds for milk homogenization. The milk was then transferred to a 40-mL collection vial containing the preservative Bronopol®.

The vials were labeled with a barcode identifying the respective farm and animal, and immediately placed in an isothermal box containing ice. The technical reports from the forwarded samples

were received, and the data referring to the milk composition were organized according to the SCC levels.
Analyses of the SCC, fat, protein, lactose, urea, casein, and DDE were performed.

Analysis of somatic cell count

The somatic cell count was analyzed by flow cytometry, with a Fossomatic 5000 Basic (Foss Electric A/S. Hillerod, Denmark). The results were expressed in somatic cells per milliliter (SC/mL).

Analysis of chemical composition

Fat, protein, lactose and DDE contents were determined by the analytical principle, with a Milkoscan 4000 (Foss Electric A/S. Hillerod, Denmark). This method is based on the differential absorption of infrared waves by the different milk components. The results were expressed as percentages (%).

Analysis of urea and casein

Urea (mg/dL) and casein (%) contents were determined using the analytical principle, with a Lactoscope (Delta Instruments). This method is based on the differential absorption of Fourier transform infrared (FTIR) spectroscopy.

Statistical analysis

A completely randomized experimental design (CRD) was used. The variables fat, protein, lactose, DDE, urea, and casein were compared according to the levels of SCC and subjected to analysis of variance. Individual means were compared using Tukey's test at a $p < 0.05$ probability level. The minimum and maximum values and coefficient of variance of milk components were determined using the WebCalc (2012) statistical software.

RESULTS AND DISCUSSION

The values of fat, protein, casein, urea, lactose and DDE were organized into different categories according to the SCC levels, as follows: under 200 thousand SC/mL, from 201 to 400 thousand SC/mL, from 401 to 600 thousand SC/mL, and above 601 thousand SC/mL (Table 1).

The minimum fat, protein and DDE levels, as percentages, that were set by Normative Instruction (InstruçãoNormativa - IN) no. 62 are 3.0, 2.9, and 8.4, respectively. The data reported in the literature are contradictory regarding the variation of milk fat content with an increasing SCC. The fat values were found to be above the minimum levels set by IN 62.

The percentage of fat increased with increasing SCC. The same result was observed by Rangel et al. (2009), when the authors evaluated the correlation between the SCC and milk components. These findings confirm that the animals were receiving adequate dietary fiber levels because the milk fat levels tend to decrease with decreasing dietary fiber content and increasing levels of non-fibrous carbohydrates (concentrate).

Bueno et al. (2005) evaluated the relationship between

Table 1. Variation in the chemical composition of milk of crossbred cows, according to the somatic cell counts.

Parameter	Up to 200 thousand SC[1]/mL	201 thousand to 400 thousand SC/mL	401 thousand to 600 thousand SC/mL	Above 601 thousand SC/mL	CV[3] (%)
	N[2] = 1317	N = 595	N = 227	N = 591	
Fat (%)	3.53[b]	3.57[b]	3.65[a, b]	3.72[a]	21.19
Protein (%)	3.27[b]	3.36[a]	3.38[a]	3.41[a]	11.18
Casein (%)	2.52[b]	2.60[a]	2.61[a]	2.62[a]	13.14
Urea (mg/dL)	15.50[a]	15.41[a]	15.14[a]	16.01[a]	32.55
Lactose (%)	4.67[a]	4.58[b]	4.50[c]	4.33[d]	5.55
DDE[4] (%)	8.91[a]	8.93[a]	8.87[a]	8.74[b]	5.39

Averages within the same row followed by the same letter are not significantly different according to Tukey's test (P<0.05). [1]SC = somatic cells. [2]N = number of collected samples. [3]CV = coefficient of variation. [4]DDE = defatted dry extract.

the SCC and components of raw milk stored in direct-expansion cooling tanks for individual use in the state of Goiás, and they found that the fat levels were similar for the group with an SCC above 601 thousand SC/mL and higher for the other groups, with values ranging from 3.71 to 3.75%. This finding is in agreement with Machado et al. (2000), who observed that an increased SCC in milk stored in tanks resulted in increased fat percentages.

This increase in fat content with an increased SCC can be explained by a decrease in the milk production by the animals and possibly in the concentration of this component. A potential explanation for this result can be found in the study by Pereira et al. (1999), who reported that, although the fat percentage generally decreases with increasing SCC, a reduction in milk production, which is more pronounced than the decrease in fat production, will result in higher fat concentrations.

Fat is the milk component that presents the highest variation. It varies according to cow breed, lactation stage, and animal diet. The genetic component and the lactation period also affect the milk lipid concentrations (González et al., 2001).

The lowest milk protein value observed was 3.27% for the group with an SCC level below 200 thousand SC/mL. The milk protein value significantly differed from the remaining groups, for which the recorded values were 3.36, 3.38, and 3.41% for the groups with an SCC from 201 to 400 thousand SC/mL, 401 to 600 thousand SC/mL and above 601 thousand SC/mL, respectively.

The protein values found in the present study were higher than the ones reported by Bueno et al. (2005), who observed protein levels between 3.18 and 3.35% for the different SCC levels studied. The milk protein concentrations increased with increasing SCC. This result is in accordance with Bueno et al. (2005), who evaluated the relationship between the SCC and components of raw milk stored in direct-expansion cooling tanks for individual use in the state of Goiás. However, Taffarel et al. (2010) found lower protein values than the ones found in the present study (between 3.15%

and 3.17%) while evaluating the effect of five SCC intervals on the milk composition.

The plasma proteins have a strong influence on the protein concentration of milk. These proteins migrate to the site of inflammation to fight the infection, increasing the milk protein concentration. However, presence of plasma proteins should not be considered favorable when evaluating the milk quality (Pereira et al., 1999). Noro et al. (2006) observed that an increase in the somatic cell score (SCS) resulted in an increase in the protein concentration of the milk.

The casein values were similar for the groups with SCC levels from 201 to 400 thousand SC/mL, 401 to 600 thousand SC/mL and above 601 thousand SC/mL (2.60, 2.61 and 2.62%, respectively) and were different from the group with an SCC below 200 thousand SC/mL (2.52%).

Santos and Fonseca (2006) reported a decrease in the casein content due to degradation by bacterial and leukocyte proteases and to decreased casein synthesis, which constitutes an undesirable effect. Decreased casein concentrations have a direct influence on dairy product production, decreasing its yield. For the dairy industry, this is a determining factor for the cheese manufacturing process.

The urea content was similar for all studied intervals, with values of 15.50 mg/dL for an SCC under 200 thousand SC/mL; 15.41 mg/dL for an SCC from 201 to 400 thousand SC/mL; 15.14 mg/dL for an SCC from 401 to 600 thousand SC/mL; and 16.01 mg/dL for an SCC above 601 thousand SC/mL. These values are within levels considered optimal for cows with a good dry matter intake, which are between 12 and 18 mg/100 mL milk (Torrent, 2000). Although the urea values were not significantly different between the different SCC levels, they did not vary greatly between groups.

This variation could be explained by unbalanced diets, especially regarding the concentrate and forage, although the values were within levels considered optimal by Gaona (2002). Urea levels between 10 and 16 mg/dL milk are considered normal. The fact that the recorded

Table 2. Mean, minimum and maximum values of fat, protein, lactose, DDE, urea and casein.

Parameter	Mean	Minimum value	Maximum value	CV[1] (%)
Fat (%)	3.59	2.0	8.4	0.21
Protein (%)	3.33	2.38	4.93	0.11
Lactose (%)	4.56	2.12	5.21	0.06
DDE[2] (%)	8.87	7.03	10.98	0.05
Urea (mg/dL)	15.5	1.4	71	0.32
Casein (%)	2.57	1.73	3.86	0.13

[1]CV = coefficient of variation. [2]DDE = defatted dry extract.

Table 3. Percentage of samples outside the standard levels established by IN 62.

Requisite	Samples outside standard levels (%)
Fat	20.4
Protein	12.0
DDE[1]	15.7
SCC[2]	21.6

[1]DDE = defatted dry extract. [2]SCC = somatic cell counts.

urea values did not vary with the studied variables indicates that the studied animals were receiving a diet with adequate, and similar, protein values. The urea content in the blood plasma, urine and milk increases linearly with increasing levels of metabolizable protein in the diet (Wang et al., 2007). The lactose content was different among all levels of SCC, with the highest value observed for the group with an SCC under 200 thousand SC/mL and decreasing values with increasing SCC levels thereafter.

The decrease in lactose content could be caused by a loss of lactose from the mammary gland into the blood due to changes in membrane permeability (Rangel et al., 2009). Decrease in milk lactose compromise milk production because lactose is responsible for attracting water into the mammary gland, and a decrease in its concentration leads to a decrease in milk production.

The milk lactose concentration decreased with an increasing SCC. This result was in accordance with Machado et al. (2000), who observed a decrease in lactose concentrations with an increasing SCC in milk stored in expansion tanks in the states of São Paulo and Minas Gerais.

The lactose levels varied, with the lowest values being found in the group of animals with an SCC above 601 thousand SC/mL. Base on the fact that lactose is an osmotic com-ponent, which is responsible for the increase or decrease of milk production, these animals were likely to be infected with subclinical mastitis and had a lower milk production. The DDE values were similar for all the SCC levels except for the group with SCC above 601 thousand SC/ml which had 8.74%.

Beloti et al. (2011) found similar values of non-fat solids

(8.9%) while evaluating the physicochemical quality of raw milk samples collected in the north of Paraná state, in the Sapopema municipality. As the levels of SCC increased, the milk DDE levels decreased slightly. The decrease in DDE may have been influenced by the increase in mammary gland permeability and possible leakage of milk components into the blood.

Ventura et al. (2006) evaluated the correlation between the SCC and milk components, and observed a decrease in DDE with an increased SCC. Rangel et al. (2009) observed a positive correlation between the SCC and DDE, with the levels of DDE increasing with increasing SCC. This finding is in contrast to the present study because the DDE level increased with the SCC levels up to 201 to 400 thousand SC/mL and then decreased at higher SCC levels.

Although there was a slight decrease in the DDE at SCC levels above 201 thousand SC/mL, this component was not greatly influenced by the SCC. This was expected because the DDE is determined by all solid components except for fat, which is the nutrient with the highest variation. From the point of view of the industry, a lower DDE content is associated with a higher dairy production yield, and this component is sometimes used as the criterion for establishing payments and bonuses to the milk producers. The data obtained for the milk components of the crossbred cows, including the mean, maximum and minimum levels and coefficient of variation, are shown in Table 2.

The mean values of fat were within the minimum levels set by IN62 (Table 3). The variation between the minimum and maximum fat values was 21%, confirming that fat is the milk component with a greater variation.

The protein levels had an 11% variation, 4.93% maximum value and 3.33% minimum value which were within the limits set by IN 62. The minimum value observed was below the adequate levels and may have been influenced by known factors such as the cow breed, stage of lactation or mammary gland diseases. There are no legal recommendations regarding lactose levels. However, it is believed that this value should be approximately 4.6%. There was little variation of the maximum and minimum values, which was expected because lactose is the milk component that varies the least. Low levels of milk lactose compromise the milk production because lactose is responsible for water absorption due to its osmotic behavior.

The mean and maximum levels of DDE agree with the levels established by the legislation. The DDE displayed the lowest coefficient of variation, confirming that the milk components that are a part of the DDE were within the levels considered optimal. The minimum value found was below the value established by the legislation. Although there are no established maximum and minimum values for the urea concentrations in milk, it is considered that in well-fed cows that receive optimal dietary fiber levels, the milk urea concentrations remain close to 12 to 16 mg/dL milk. The mean values observed are within those levels; however, the minimum and maximum values were outside the levels considered to be optimal. A high milk urea content indicates protein supplementation that exceeds the required amount (Torrent, 2000).

The mean value of casein was 2.57%. There are no minimum and maximum casein levels established by the legislation. Philpot (1998) reported that inflammatory processes in the mammary gland increase with increasing concentrations of the plasmin enzyme in the milk, thereby increasing casein degradation and decreasing stability.

The values established by IN 62 for fat, protein, DEE and SCC are shown in Table 3. Although the number of samples studied was large, a great part of those samples exhibited fat values outside the standard levels. Approximately 20.4% of the samples had less than 3.0% fat, although the fat content displayed a great variation. This fact confirms that the studied animals were receiving a diet which was low in fiber.

The lower values found for protein content were outside the standard levels, amounting to 12.0% of the samples. The remaining 88% of the studied samples had protein levels higher than 2.9%, which is the lower limit established by the legislation. Because the DDE comprises all solid components of milk except for fat, the number of samples with values outside the standard levels (15.7%), even though fat had no influence, indicates that the milk composition was affected by the SCC. The SCC might have affected the permeability of the mammary gland membranes, causing the milk components to disperse into the blood.

The SCC was a determinant factor for the milk com-

position and for the percentage of samples that fell outside the standard levels because approximately 21.6% of the samples had SCC levels above 600 thousand SC/mL. This is considered to be very high and indicative of subclinical infection of mastitis in the animals. Attention should be given to these animals because they may increase the SCC levels of the herd's tank, which would result in lower returns from the industry to the producer.

Conclusions

Urea concentrations did not vary with increasing somatic cell counts. Lactose decreased with increasing somatic cell counts. Defatted dry extract was minimally influenced by increasing somatic cell counts. The results were found while considering the somatic cell levels within the standards established by IN 62/2011.

Conflict of interests

The authors did not declare any conflict of interest.

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