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ARTÍCULO ORIGINAL

Relationship between somatic cell counts and milk production and composition in Jersey cows

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ABSTRACT: The main components in milk from cows that are affected by mastitis can be in different amounts according to the racial characteristics. Thus, the association between the somatic cell counts (SCC) and these components may also differ in milk from Jersey cows. This study evaluated the effect of the SCC in milk from Jersey cows on milk production and its physicochemical composition. For 71 months, data from 3244 milking and 300 cows were evaluated considering the effect of the SCC on milk production (kg cow day^{-1}), percentage of fat, protein, lactose, total solids, and nonfat solids. The probable factors associated with fluctuation in milk production based on somatic cell score, lactation number and rainfall were also evaluated by regression models. Milk composition was changed according to the SCC. In general, the higher the SCC in milk, the lower the contents of lactose, fat, and solids, with exception of the protein content, which increased. Losses in milk production of Jersey cows were observed for milk with counts above 50,000 somatic cells per ml.

Key words: productivity, mastitis, lactose, protein, losses.

Relación entre el recuento de células somáticas y la producción y composición de leche en vacas Jersey

RESUMEN: Los principales componentes de la leche en vacas que tienen mastitis pueden estar en diferentes cantidades de acuerdo con la raza. Por lo tanto, la asociación entre el recuento de células somáticas (RCS) y estos componentes también pueden diferir en la leche de vacas Jersey. Este estudio evaluó el efecto del RCS en leche de vacas Jersey en la productividad y la composición físico-química. Durante 71 meses se evaluaron los datos de 300 vacas y 3 244 ordeños; para ello se consideraron el efecto de RCS en la producción de leche (kg/vaca/día), el porcentaje de grasa, la proteína, la lactosa, los sólidos totales y los sólidos no grasos. Los probables factores asociados con las fluctuaciones en la producción de leche, sobre la base de la puntuación de células somáticas, número de lactaciones y precipitación de lluvia; también se evaluaron por regresión lineal. La composición de la leche estuvo influenciada por el RCS. En general, cuanto mayor fue el número de células somáticas en la leche, menor fue el contenido de lactosa, de grasa y de sólidos, con excepción del contenido de proteínas que se incrementó. Se observaron pérdidas en la producción de leche en vacas Jersey para la leche con recuentos superiores a 50 000 células somáticas/ml.

Palabras clave: productividad, mastitis, lactosa, proteína, pérdidas.

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INTRODUCTION

The effect of clinical and/or subclinical mastitis on milk composition is being extensively studied since the 70s. Besides the increase in somatic cell counts (SCC) in milk, major changes occur in the levels of lipids, proteins and lactose (1). However, little information is found in literature when these studies are sectored by breeds.

The Jersey breed is among the most numerous in southern Brazil, as both purebred cattle and their crossbreds. The largest herd in the country is located in the state of Santa Catarina, with about 37.000 heads. In Rio Grande do Sul, the number of Jersey breed is second only to the Dutch breed. Worldwide, this breed stands out, and New Zealand is the country with the largest herd with more than 800.000 heads. These data show the importance of this breed in the country and in the world (2).

In Brazil, most scientific papers describe the production characteristics and composition according to the somatic cell counts in Dutch, Gir, and crossbred cows (3, 4, 5). However, there are no studies comparing these variables exclusively for the Jersey breed.

The main components that are affected by mastitis, such as proteins, solids, and lactose are in different amounts according to the racial characteristics. Thus, the association between SCC and these components may also differ in the milk from Jersey cows (6).

Losses caused by mastitis can be measured by comparing both the productivity of the animals and the SCC in milk. According to Halasa *et al.* (7) in healthy cows, the greater the SCC increase above 100.000 cells ml^{-1}, the greater the production losses, with average losses of 0.60 kg of milk per day. According to Hagnestam (8), the magnitude of the yield losses depends on the week of lactation, with the greatest losses occurring in primiparous cows. Philpot (9) found losses of 2.5% in milk production for every 100,000 cells ml^{-1} above the basal level of 200.000 cells ml^{-1}.

This study aimed to evaluate the milk production and composition of Jersey cows in relation to the SCC, and the likely factors associated with these changes.

MATERIALS AND METHODS

From January 2006 to December 2012, 300 Jersey cows were monitored by the Paraná Association of Dutch Cattle Breeders (APCBRH), totaling 3244 milkings in a 71 month-period. The animals were grazing on *Cynodon* sp., supplemented with corn silage and concentrate, and milked twice a day.

After milking, the milk was homogenized and approximately 50 ml were collected in polyethylene bottles containing bronopol for determining the chemical composition by an infrared method (10).

The vials were sent to the APCBRH laboratory, and the contents of fat, protein, lactose, total solids (TS), nonfat solids (NFS), and somatic cell counts (SCC) were determined.

Data on days in milk were categorized as milk test-day number, which was done each 30 days within each lactation. To get data normality for the statistical analysis, the SCC was transformed into somatic cell linear scores (SCLS) by applying the following equation: SCS = [log2 (SCC/100)] + 3 animals, as proposed by Shook and Shultz (11), categorically ranging from 0 to 9.

The design was completely randomized and data on animals and production were analyzed by descriptive statistics and by ANOVA to identify the variable effects. All the variables with significant effects ($p<0,05$) on the parameters studied were fixed in the model to determine the effects of the somatic cell counts by least square regression analysis, using the General Regression Models (GRM) of Statistical 10.0, as follows:

$$Y_{ijklm} = \mu + YEA_i + LAC_j + DIM_k + PRO_l + SCS_m + e_{ijklm}$$

where: Y*ijklm* = observation of the milk component concentration within each SCS; μ = overall mean; YEA*i* = fixed effect of the year (*i* = 1, 2, ..., 7); LAC*j* = fixed effect of lactation number (*j* = 1, 2, ..., 11); DIM*k* = fixed effect of days in milk categorized as milk test-day number within each lactation (*k* = 1, 2, ..., 14); PRO*l*: fixed effect of milk yield (*l* = 2, ..., 38); SCS*m*: linear effect of somatic cell score within each SCS (*m* = 0, 1, ..., 9) and e*ijklmn* = residual error. To determine the effects of the SCS on milk yield, PRO*l* were removed from the model.

RESULTS AND DISCUSSION

The results of the parameters are shown in Table 1. Both, the daily productivity and the milk composition, were similar to those reported by other authors (12, 13). These characteristics are also consistent with the average production of the northern region of the state, which can vary from 7 to 18 Kg / day (2). However, when comparing the proximate composition with that found in animals from countries like the United States or Argentina, the contents of fat, lactose and TS were below the values reported by Ordonez (14), Fox and McSweeney (15), who found values of 5.5%, 4.5%, and 15%, respectively, for milk from Jersey cows.

TABLE 1. Average values, range (min-max) and standard deviation (SD) of milk production (kg/cow/day) and composition of 300 lactating Jersey cows, from January 2008 to December 2012, total of 3244 observations./ *Valores promedios, rango (mín-max) y desviación estándar (SD) de la producción (kg/vaca/día) y composición de leche de 300 vacas Jersey, entre enero de 2008 y diciembre de 2012, total de 3244 observaciones.*

	Average	Min-Max	SD
Milk production (Kg cow day^{-1})	14.46	2.00 - 38.00	5.01
Lactation (numbers	3.15	1 -11	2.08
of lactation in a 71 month-period)	3.15	1 -11	2.08
Animal age (year)	6.03	2.11 - 3.01	2.55
Fat (%)	4.38	2.01 - 6.79	0.86
Protein (%)	3.76	2.78 - 4.77	0.37
Lactose (%)	4.45	3.59 - 5.19	0.27
TS (%)	13.58	10.64 - 16.57	1.07
NFS (%)	9.20	7.05 - 11.19	0.45
SCC (cells/mL.10^{3})	381.61	1 - 9500	619.00
SCS	3.59	0 - 9	2.01
Rainfall (mm^{3})	125.27	0.00 – 489.40	91.14

Rainfall associated with the temperature oscillation helps to determine the thermal comfort index (TCI), which predicts about the environmental conditions to which the animals are subjected. According to the Brazilian National Institute of Meteorology, the TCI during the study period did not exceed 74 (16). Battaglini *et al.* (12) found similar values and concluded that these conditions were mild for crossbred and zebu cattle. For European lactating dairy cows, values lower than 74 are recommended, since daily somatic cell score patterns can increase values at both lowest and highest ranges, with a more pronounced reaction to cold stress for apparent temperature indices (17).

The values found for the milk components according to the SCS are shown in Table 2. When the physicochemical composition of milk with score zero was compared with the other scores, significant differences ($p<0.01$) were observed for protein, fat, lactose, TS, and NFS. In general, the higher the SCC in milk is, the lower the average percentages are, except for the protein content.

The lactose content showed the highest correlation value, -0.55 ($p<0.001$). Thus, it is possible to infer that, considering the milk from Jersey cows, in 55% of the cases, the increase in SCC was related to the decrease of lactose content. Prada and Silva *et al.* (18) studied the milk of dairy cows from different races, and concluded that approximately 34% of lactose variation could be explained by the increase of SCS.

This sugar is the most responsible for the osmotic gradient, determining the volume of milk to be produced. This fact can be associated with the effectiveness of lactose level as a predictor of milk quality in cows, sheep and goats (19). In sub-clinical inflammation of the udder, there is a change in the cellular junctions of the epithelial cells of the mammary gland, allowing a greater passage of salts from blood into the milk. All tissue secretion is impaired, also affecting the rate of lactose synthesis, which is always in smaller amounts in milk from herds with mastitis. The glandular edema also makes difficult the arrival of glucose at the gland (20).

Lactose represents 45 to 55% of the total solids in milk (21). Therefore, lactose content decreases can be accompanied by reduction of solids, which could be observed in this study. Both the TS and NFS contents decreased ($p<0.01$) when increasing the SCS, since the increase in SCC was associated with the decrease in solids content in up to 34% cases ($r=-0.34$; $p<0.01$). Fernandez *et al.* (22) also found a negative correlation with TS, but only when the SCC was higher than 10^{6} cells ml^{-1}.

Prada and Silva *et al.* (18) did not find a relationship between solids and SCS. In this case, the increased

TABLE 2. Relationship between milk composition per somatic cell score (SCS) and yield losses (%) when compared with the highest average percentage (*dif*) of milk components of Jersey cows, as well as the correlation coefficients (r) with somatic cell score in 3244 observations./ *Relación entre composición de la leche por escore de células somáticas (SCS) y pérdidas (%) en comparación con el mayor porcentaje medio (dif) de componentes de la leche de vacas Jersey, y coeficiente de correlación (r) con escore de células somáticas en 3.244 observaciones.*

		Protein		Fat		Lactose		TS		n[2]
SCS	SCC[1]	%	losses	%	losses	%	losses	%	losses	
0	1-17	3.64	4.17	4.25	3.98	4.62	-	13.52	0.89	312
1	18-35	3.66	3.48	4.25	3.93	4.59	0.68	13.52	0.90	233
2	36-70	3.68	2.95	4.25	4.00	4.57	0.96	13.53	0.84	380
3	71-141	3.72	1.84	4.38	1.12	4.52	2.05	13.64	0.03	637
4	142-282	3.75	1.06	4.42	0.12	4.46	3.38	13.64	-	625
5	283-565	3.79	-	4.43	-	4.41	4.57	13.63	0.07	512
6	566-1123	3.78	0.31	4.41	0.40	4.31	6.73	13.48	1.23	310
7	1132-2257	3.74	1.48	4.40	0.51	4.32	6.52	13.45	1.44	179
8	2300-4421	3.77	0.66	4.32	2.34	4.24	8.10	13.31	2.41	47
r (*p*)		-0,46 (0,001)		0,29 (0,001)		0,55 (0,001)		0,34 (0,001)		

[1] Somatic cell count in cells ml 10^{-3}; [2]Number of obsrevations.

passage of salts and whey proteins from blood to milk may overcome the deficit of lactose synthesis, which is expected in less severe subclinical mastitis, with lower SCC (21).

The fat content also decreased with increasing SCS, with a correlation value of -0.29 at p<0.01. According to Fox and McSweeney (15), the mammary gland edema damaged the cell detachment within two tenths when compared with milk with SCS zero.

An opposite effect was observed for the protein content, since it increased with SCS increases, with a correlation value of 0.46 at p<0.01. The method used in this study determined protein content as both casein and whey proteins. Due to the increased vascular permeability caused by inflammation, whey proteins content may be higher in milk with high SCC, when this phenomenon overcomes the deficit in casein synthesis (23). This fact could be observed in the milk from Jersey cows. Some serum proteins, like cellular proteins and lactotransferrin, are only detected in samples from animals with mastitis (23).

To estimate the losses related to the SCC increase, the average milk production with SCS zero was compared with other scores. Table 3 shows the values of daily milk production, and production losses according to the somatic cell scores.

When compared to the SCS zero, losses in milk production of Jersey cows were lower (p<0.05) for milk over 50 000 somatic cells per ml (SCS 2). A production loss in milk with SCS 8 was 30% higher than in milk with SCS zero. According to Halasa et al. (7), in normal healthy cows, the SCC is less than 50 million ml^{-1}. In contrast, Hortet and Seegers (24) found losses of 2.5% in milk production for every 100 000 cells ml^{-1} above the basal level of 200 000 cells ml^{-1}.

From the SCS 5, the average production was lower (p<0.05) than with the SCS 2, 3, and 4. Thus, the productivity can be even lower from 400 000 cells ml^{-1}. The SCS 8 exhibited the lowest (p<0.05) productivity, with a difference higher than 30% when compared with SCS zero.

Coldebella et al. (25) found milk production losses of 0.238 day^{-1} and 0.868 day^{-1} for primiparous and multiparous cows, respectively, per each SSC logarithmic unit over 17 000 cells ml^{-1}. Kirk (26) observed losses of 0.34 and 0.68, and Reneau (27) 0.27 and 0.59 kg milk day^{-1} for primiparous and multiparous cows, respectively, from 100 000 cells ml^{-1} milk. In all studies the losses increased with increasing SCC. Tesfaye, Regassa and Kelay (28) stated that a quarter with mastitis could lose an average of 34.5% of its potential milk production while the total milk yield loss per cow was estimated in 6.8%.

The drop in productivity is also explained by the reduced lactose synthesis in the mammary gland, since this sugar is directly related to osmotic balance, acting as the solute that guides the passage of solvent from blood to milk. Thus, milk with a decrease in lactose will have smaller amounts of solvent, reflecting on milk production (29).

TABLE 3. Relationship between milk production (kg/cow/day) with somatic cells scores (SCE) and losses (% kg/cow/day) when compared with the highest milk production of Jersey cows, in 3244 observations from January 2008 to December 2012./ *Relación entre la producción de leche (kg/vaca/día) con escores de células somáticas (SCE) y pérdidas (%) (kg/vaca/día) en comparación con la mayor producción de leche de vacas Jersey en 3244 observaciones desde enero de 2008 hasta diciembre de 2012.*

SCE	SCC[1] (cellsmL 10^{-3})	n[2]	Milk production (kg cow day-1)	Losses (%)	Stand. error
0	1-17	312	15.26	5.66	0.23
1	18-35	233	16.18	-	0.27
2	36-70	380	15.30	5.40	0.21
3	71-141	637	15.45	4.53	0.16
4	142-282	625	14.91	7.86	0.17
5	283-565	512	14.79	8.59	0.18
6	566-1123	310	14.45	10.68	0.24
7	1132-2257	179	14.64	9.52	0.31
8	2300-4421	47	13.18	18.55	0.60
9	4597-7017	9	10.46	35.37	1.38

[1]Somatic cell count; [2]Number of observations.

CONCLUSIONS

In general, the higher the somatic cells count in milk, the lower the contents of lactose, fat and solids, except for the protein content, which increased with increasing SCC. The SCC also influenced the production for milk containing over 50.000 somatic cells ml^{-1}, with 30% losses. Thus, the Jersey breed has the same variation of other breeds, but further studies can assess significant differences between breeds.

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