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RELATIONSHIP BETWEEN SOMATIC CELL COUNTS AND COMPOSITION OF MILK FROM INDIVIDUAL HOLSTEIN COWS

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ABSTRACT

In the present study, the relationship between somatic cell counts (SCC) and composition (total solids, fat, protein and lactose content) of milk from individual Holstein cows was investigated in two different farms. Farm A had 43 lactating cows and produced bulk milk with mean SCC below 500,000 cells / mL. Farm B had 38 lactating cows that produced bulk milk with SCC usually above 1,000,000 cells / mL. Milk samples were collected three times from all lactating cows in both farms, with 60-day intervals between collections. Milks from farm A presented mean SCC levels that ranged from 143,000 to 549,000 cells / mL, while counts in farm B ranged from 1,187,000 to 3,432,000 cells / mL. SCC produced positive correlations ($p < 0.05$) only with protein content in farm A. A significant negative relationship ($p < 0.05$) was observed between log SCC and total solids and lactose in farm B. The results indicate that SCC of individual cow's milk significantly correlate with a decrease in milk constituents only under conditions of average SCC in bulked milk above 1,000,000 cells / mL.

KEY WORDS: SCC, milk composition, analysis.

RESUMO

RELAÇÃO ENTRE A CONTAGEM DE CÉLULAS SOMÁTICAS E A COMPOSIÇÃO DO LEITE INDIVIDUAL DE VACAS HOLANDESAS. No presente estudo, a relação entre a contagem de células somáticas (CCS) e a composição (sólidos totais, gordura, proteína e lactose) do leite individual de vacas holandesas foi investigada em duas diferentes fazendas. Na fazenda A havia 43 vacas em lactação e produção de leite de mistura com CCS média abaixo de 500.000 céls / mL. Na fazenda B havia 38 vacas em lactação, produzindo leite de mistura com CCS acima de 1.000.000 céls / mL. As amostras de leite foram coletadas três vezes, de todas as vacas em lactação, nas duas fazendas, com intervalo de 60 dias entre as coletas. Os leites da fazenda A apresentaram níveis médios de CCS variando de 143.000 a 549.000 céls / mL, enquanto que as contagens na fazenda B variaram de 1.187.000 a 3.432.000 céls / mL. Houve correlação positiva da CCS ($p < 0,05$) somente com os teores de proteína na fazenda A. Foi observada correlação negativa ($p < 0,05$) entre o log CCS, sólidos totais e lactose na fazenda B. Os resultados indicam que a CCS do leite individual de vacas correlaciona-se significativamente com o decréscimo nos constituintes do leite somente sob condições de CCS média no leite de mistura acima de 1.000.000 céls / mL.

PALAVRAS-CHAVE: CCS, composição do leite, análise.

INTRODUCTION

The composition of milk is markedly influenced by the health status of the udder. The occurrence of inflammatory process or mastitis generally leads to an increase in somatic cell counts (SCC) in milk, which has been associated with changes in milk components and properties (Auldist & Hubble, 1998). These changes may occur both in the main constituents of fluid milk, such as lactose, proteins and fat, and in minor components, such as minerals and enzymes.

Several studies have reported decreases in lactose concentration in the milk of cows presenting high SCC (Miller et al., 1983; Rogers et al., 1989; Auldist et al., 1995; Silva et al., 2000). A negative correlation was observed between the percentage of lactose in milk and the severity of the disease (Miller et al.,

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1983). According to MILLER et al. (1983), mastitis determines a continuous reduction in lactose concentration in milk with SCC above 100,000 cells / mL. KLEI et al. (1998) demonstrated that when SCC increases from 83,000 cells / mL to 870,000 cells / mL, lactose concentration is reduced from 4.977% to 4.707%.

Experimental results are not clear in relation to the effects of high SCC milk on the concentration of total protein content in milk as measured by total nitrogen content. Several authors reported that milk of cows presenting high SCC presented greater contents of total protein when compared with the milk of healthy cows (WEAVER & KROGER, 1977; MILLER et al., 1983; AULDIST et al., 1995; KLEI et al., 1998; PEREIRA et al., 1999). On the other hand, HAENLEIN et al. (1973), MITCHELL et al. (1986) and VERDI et al. (1987) did not observe differences between total protein contents in the milk with high SCC and that of healthy cows, whereas ROGERS et al. (1989) and LEE et al. (1991) reported a reduction in total protein contents in the milk from cows presenting high SCC.

Fat concentration may be reduced in milk presenting high SCC because of the decrease in fat synthesis by epithelial cells of the mammary gland (RANDOLPH & ERWIN, 1974; SCHULTZ, 1977). However, some studies have indicated that, similar to SCC effects on total protein content in milk, correlation between SCC and fat percentage may be negative, positive or null (SCHULTZ, 1977; MUNRO et al., 1984; PEREIRA et al., 1999). Moreover, correlation between these parameters and SCC in the milk from herds with low and high counts is not fully understood.

The aim of the present study was to investigate the correlation between SCC and composition (total solids, protein, fat and lactose content) of milk from individual cows in two farms, one presenting low SCC in bulk milk (up to 500,000 cells / mL), and another where bulk milk presented high SCC (above 1,000,000 cells / mL).

MATERIAL AND METHODS

Milk collection

This study used Holstein cows that were in intermediate stages of lactation, and had not been submitted to treatment with antibiotics seven days before milk collection. Milk analyses were conducted three times, in March, May and July 2003, in two farms located in the city of Pirassununga, state of São Paulo, Brazil. Feeding management of the farms was not altered during the sampling. Farm A had 43 lactating cows and produced bulk milk with SCC below 500,000 cells / mL, which complies with most SCC limits legally determined in several countries. Farm B had 38 lactating cows that produced bulk milk with SCC usually above 1,000,000 cells / mL, that is, above limits determined internationally for this quality standard.

SCC and composition analysis

Milk samples were collected from each cow immediately after the end of the milking procedure. Thirty mL were collected after homogenisation of total milk produced from each cow, in the morning and in the afternoon milking, resulting in a total sample equal to 60 mL. Samples were placed in flasks containing 8mg of Bronopol (2-bromo-2-nitropropane-1,3-diol) as a preserving agent and were stored under refrigeration until the moment of analysis. Milk samples were submitted two days after the collection to somatic cell counts by flow cytometry in an electronic counter (Bentley, Chaska, Minnesota, USA). Composition (total solids, fat, protein and lactose content) analysis was achieved using a Bentley (Chaska, Minnesota, USA) mid-infrared analyser.

Statistical analyses

SCC values were transformed in $\log_{10}$. Data obtained in each farm were submitted to one-way ANOVA, and parameter means were compared by the Tukey test. Results for milk composition from all samples collected in each farm were used to determine Pearson's Correlation Coefficient (r) between log SCC values and total solids, lactose, protein and fat content. Student's t test with normal approximation was used in the comparison of correlation coefficients at a 5% level of significance (GACULA & SINGH, 1984).

RESULTS AND DISCUSSION

Values for log SCC and milk composition in farms A and B in March, May and July are presented in Table 1. Mean SCC in farm A increased constantly, from 143,000 cells / mL in March to 180,000 cells / mL in May, to 549,000 cells / mL in July. In farm B, SCC levels were greater than in farm A, with values ranging from 2,330,000 and 1,187,000 cells / mL in March and May, respectively, and 3,432,000 cells / mL in July. Total solids contents increased in farm A in May, when compared with March ($p < 0.05$), followed by a decrease in July ($p < 0.05$). In farm B, values decreased with the increase in SCC, reaching a mean value equal to 10.62% with 550,000 cells / mL, and only 8.27% when SCC was around 3,400,000 cells / mL (Table 1).

Table 1 – Average values of somatic cell counts and composition parameters of milk of individual cows in farms A and B, analysed in three different months.[1]

Parameter	Month of analysis		
	March	May	July
Farm A			
Somatic cell count (log cells / mL)	4.91 ± 0.52 [a]	5.00 ± 0.55 [a]	5.17 ± 0.66 [a]
Total solids (%)	11.86 ± 0.71 [a]	12.42 ± 0.84 [b]	11.02 ± 0.70 [c]
Lactose (%)	4.56 ± 0.23 [a]	4.49 ± 0.22 [a]	4.36 ± 0.21 [b]
Fat (%)	3.52 ± 0.42 [a]	3.92 ± 0.57 [b]	2.75 ± 0.47 [c]
Total protein (%)	2.91 ± 0.33 [a]	2.99 ± 0.42 [a]	2.97 ± 0.29 [a]
Farm B			
Somatic cell count (log cells / mL)	5.89 ± 0.73 [ab]	5.72 ± 0.61 [a]	6.30 ± 0.47 [b]
Total solids (%)	10.07 ± 1.33 [a]	10.62 ± 1.16 [a]	8.27 ± 0.98 [b]
Lactose (%)	4.31 ± 0.58 [a]	4.36 ± 0.52 [a]	3.62 ± 0.58 [b]
Fat (%)	1.87 ± 0.84 [a]	1.88 ± 1.06 [a]	1.15 ± 0.40 [b]
Total protein (%)	3.11 ± 0.39 [a]	3.64 ± 0.34 [b]	3.02 ± 0.28 [a]

[1]Mean ± standard deviation of milk samples collected from 43 cows in farm A and 38 cows in farm B.
[a,b,c] Within a row, means followed by the same letter are not significantly different ($p > 0.05$).

Lactose content decreased progressively with an increase in SCC in the two farms, reaching the lowest value in July ($p < 0.05$), which is different from the results reported by Miller et al. (1983). In farm A, values ranged from 4.56% to 4.36% when SCC were 143,000 and 550,000 cells / mL respectively (Table 1). Lactose contents in farm B were below those observed in farm A, reaching only 3.62% when SCC was 3,400,000 cells / mL.

There was an increase in fat percentage in farm A in May, when compared with March ($p < 0.05$), although there was an increase in SCC (Table 1). According to some authors, (Schultz, 1977; Munro et al., 1984; Pereira et al., 1999) high SCC may lead to an increase, a reduction or no change in the fat content of milk. Auldist et al. (1995) reported that milk containing more than 300,000 cells / mL presented less fat. In fact, lower fat content was observed in July ($p < 0.05$), when SCC was greater than 550,000 cells / mL.

There was a non-significant ($p > 0.05$) increase in total protein contents together with SCC increase throughout the year in farm A. This observation is in accordance with the reports that show that milk with high SCC presents greater total protein contents when compared with low SCC milk (Weaver & Kroger, 1977; Miller et al., 1983; Auldist et al., 1995; Klei et al., 1998; Pereira et al., 1999). However, in farm B, there was a decrease in the percentage of total protein in July when compared to May ($p < 0.05$), which indicates that lower protein contents may be observed in milk with high SCC, as reported by Rogers *et al.* (1989).

Table 2 presents correlation coefficients for SCC levels and total solids, lactose, fat and total protein contents. In farm A, a positive correlation ($p < 0.05$) was only observed between SCC and total protein content. According to Schultz (1977), there is an increase in vascular permeability in the beginning of the mastitis process, which determines a greater flow of serum proteins into the milk, which balances the decrease in protein synthesis by the mammary gland. This fact may have contributed for the positive correlation observed between SCC and total protein in farm A. On the other hand, correlations obtained between SCC and total solids, lactose or fat contents in farm A were not significant ($p > 0.05$).

In farm B, a negative correlation ($p < 0.05$) was observed between SCC and total solids, and between SCC and lactose contents (Table 2), which is in accordance with previous results obtained by Miller et al. (1983), Rogers et al. (1989), Auldist et al. (1995) and Klei et al. (1998). Silva et al. (2000) also observed that SCC negatively affected lactose content, but they did not obtain any correlation between high SCC and total solids. Reduction in lactose contents in milk presenting high SCC, according to Shuster et al. (1991), may be due to the passage of lactose from milk into blood.

Table 2 – Correlation coefficients (r) between log somatic cell count (SCC) and composition parameters of milk of individual cows in farms A and B[1].

Parameters	Farm A (r)	Farm B (r)
Total solids	0.12	- 0.44*
Lactose	- 0.14	- 0.71*
Fat	0.02	- 0.02
Total protein	0.43*	- 0.03

[1]N = 129 and 114 for farms A and B, respectively.
*$p < 0.05$

Total protein and fat contents did not produce significant correlations ($p > 0.05$) with SCC levels in farm B, which is in agreement with data reported by HAENLEIN et al. (1973), MITCHELL et al. (1986) and VERDI et al. (1987).

CONCLUSIONS

Results of this trial suggest that SCC of individual cow milk may correlate significantly with decrease in total solid and lactose content only when average SCC is above 1,000,000 cells / mL. SCC positively correlated with total protein content only in milk presenting SCC below 500,000 cells / mL, while no correlation between SCC and fat was observed, neither in cows presenting low or high SCC.

REFERÊNCIAS BIBLIOGRÁFICAS

AULDIST, M.J.; COATS, S.; ROGERS, G.L.; MCDOWELL, G.H. Changes in the compositional of milk from normal and mastitic dairy cows during the lactation cycle. *Aust. J. Exp. Agric.*, v.35, p.427-436, 1995.

AULDIST, M.J. & HUBBLE, I.B. Effects of mastitis on raw milk and dairy products. *Aust. J. Dairy Technol.*, v.53, p.28-36, 1998.

GACULA, J.R. & SINGH, J. *Statistical methods in food and consumer Research.* Orlando: Academic Press, 1984. 505p.

HAENLEIN, G.F.W.; SCHULTZ, L.H.; ZIKAKIS, J.P. Composition of proteins in milk with varying leucocyte contents. *J. Dairy Sci.*, v.56, p.1017-1024, 1973.

KLEI, L.; YUN, J.; SAPRU, A.; LYNCH, J.; BARBANO, D.; SEARS, P.; GALTON, D. Effects of milk somatic cell count on Cottage cheese yield and quality. *J. Dairy Sci.*, v.81, p.1205-1213, 1998.

LEE, S.C.; YU, J.H.; JEONG, C.L.; BACK, Y.J.; YOON, Y.C. The influence of mastitis on the quality of raw milk and cheese. *Korean J. Dairy Sci.*, v.13, p.217-223, 1991.

MILLER, R.H.; EMANUELSSON, U.; PERSSON, E.; BROLUND, L.; PHILIPSSON, J.; FUNKE, H. Relationships of milk somatic cell counts to daily milk yield and composition. *Acta Agric. Scand.*, v.33, p.209-223, 1983.

MITCHELL, G.E.; FEDRICK, I.A.; ROGERS, S.A. The relationship between somatic cell count, composition and manufacturing properties of bulk milk. Cheddar cheese from farm bulk milk. *Aust. J. Dairy Technol.*, v.41, p.12-14, 1986.

MUNRO, G.L.; GRIEVE, P.A.; KITCHEN, B.J. Effects of mastitis on milk yield, milk composition, processing properties and yield and quality of milk products. *Aust. J. Dairy Technol.*, v.39, p.7-16, 1984.

PEREIRA, A.R.; SILVA, L.F.; MOLON, L.K. Efeito do nível de células somáticas sobre os constituintes do leite. I - gordura e proteína. *Braz. J. Vet. Res. Anim. Sci.*, v.36, p.0-0, 1999. ISSN 1413-9596.

RANDOLPH, H.E. & ERWIN, R.E. Influence of mastitis on properties of milk. X. Fatty acid composition. *J. Dairy Sci.*, v.57, p.865-868, 1974.

ROGERS, S.A. & MITCHELL, G.E. The relationship between somatic cell count, composition and manufacturing properties of bulk milk. 6. Cheddar cheese and skim milk yoghurt. *Aust. J. Dairy Technol.*, v.49, p.70-74, 1994.

ROGERS, S.A.; SLATTERY, S.L.; MITCHELL, G.E.; HIRST, P.A.; GRIEVE, P.A. The relationship between somatic cell count, composition and manufacturing properties of bulk milk 3. Individual proteins. *Aust. J. Dairy Technol.*, v.44, p.49-52, 1989.

SILVA, L.F.P.; PEREIRA, A.R.; MACHADO, P.F.; SARRIÉS, G.A. Efeito do nível de células somáticas sobre os constituintes do leite. II - lactose e sólidos totais. *Braz. J. Vet. Res. Anim. Sci.*, v.37, p.00-00, 2000. ISSN 1413-9596.

SCHULTZ, L.H. Somatic cells in milk-physiological aspects and relationship to amount and composition of milk. *J. Food Prot.*, v.40, p.125-131, 1977.

SHUSTER, D.E.; HARMON, R.J.; JACKSON, J.A.; HEMKEN, R.W. Suppression of milk production during endotoxin-induced mastitis. *J. Dairy Sci.*, v.74, p.3763-3774, 1981.

VERDI, R.J.; BARBANO, D.M.; DELLAVALLE, M.E.; SENIK, G.F. Variability in true protein, casein, nonprotein nitrogen, and proteolysis in high and low somatic cell milks. *J. Dairy Sci.*, v.70, p.230-242, 1987.

WEAVER, J.C. & KROGER, M. Protein, casein, and non protein percentages in milk with high somatic cell counts. *J. Dairy Sci.*, v.60, p.878-881, 1977.

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