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A Study on Relationships Between Somatic Cell Count (SCC) and Some UdderTraits in Dairy Cows

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Abstract: In this study, the relationships between Somatic Cell Counts (SCC), in milk samples obtained from 110 cows in 2 different barns and udder traits classified by using objective and subjective measures, were investigated. Stage of lactation was determined to have effect on SCC and log SCC and the residuals of objective measures were calculated. Squared multiple correlation (R^2) values, calculated from residuals were found to be small for objective measures (0.08-0.17). In step 1, in which multiple linear coefficients were calculated, teat diameter, fore udder height and rear udder height values were demonstrated to be statistically significant ($p<0.05$); whereas in the last stage, although, teat diameter and fore teat height values were determined to be statistically significant ($p<0.05$), rear teat height was demonstrated to be insignificant and was removed from the model. Teat end shape was determined to have effect on log SCC, whereas udder form and localization of the udder lobe were found to be ineffective.

Key words: Somatic cell count, udder form, teat end shape, teat diameter, udder height

INTRODUCTION

In the dairy industry, milk quality is as significant as the amount of milk production. The number of epithelial cells and leucocytes (somatic cells) normally found in milk, increase in case of mammary infection (mastitis). As Somatic Cell Count (SCC) increases, milk yield and the fat and protein content of milk decrease (Welper and Freeman, 1992). Furthermore, the shelf-life of milk and milk products shortens (Ma *et al*., 2000). Therefore, in many countries, milk with higher SCC values is quoted lower prices, whereas milk with SCC values exceeding the acceptable limits are rejected (Packard and Ginn, 1985). Costs of medication and veterinary services for mastitis treatment reduce the profitability of holdings (Shim *et al*., 2004).

Long-term sub chronic and chronic mastitis may lead to the atrophy of udder lobes, which are the basic resource of milk production and thereby may result in the early culling of animals with high milk yields (Deveci *et al*., 1994). Displaying a quite complex ethiology, mastitis, under present circumstances, is not considered to be able to be completely eradicated. This situation has canalized researchers to study on the breeding of animals less susceptible to mastitis. In these studies, dairy cows with high milk yields have been determined to display higher incidence of mastitis (Wilton *et al*., 1972; Gonyon *et al*., 1982; Kennedy *et al*., 1982). This situation constitutes a handicap for selection studies aimed at the reduction of SCC in milk. Therefore, the evaluation of relationships between SCC in milk and various udder and teat traits and the development of new selection criteria for the reduction of mastitis incidence have started to gain significance.

For this purpose, the present study was aimed at the evaluation of udder and teat traits measured by using objective and subjective measures, as well as the influence of the indicated values on SCC and the relationship of these values with SCC.

MATERIALS AND METHODS

The data used in the present study were obtained from 110 dairy cows pertaining to Ataturk University, Faculty of Agriculture and the East Anatolian Agricultural Research Institute, in Erzurum city, Turkey. Both farms were visited 4 times, during 4 months and the evaluation of udder and teat traits and the collection and analyse of milk samples were performed on the same day.

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Collection of milk samples: Following the disinfection of teats with alcohol, milk samples were collected from each teat into tubes and were transferred to the laboratory. Within 24 h of collection, the milk samples were spread on 2 microscope slide areas, which were 5×20 mm^2 in size. Subsequently, the slides were fixed at 37°C in an incubator and the nuclei of leucocytes and epithelial cells existent in the milk samples were stained by means of the application of a dye solution containing methylene blue. In each slide, counts were performed in 20 fields under a 100x immersion objective and means were calculated. The SCC in 1 mL of milk was calculated by the multiplication of these mean values with the microscope factor (Packard and Ginn, 1985).

Udder and teat measures: The length of each teat was measured perpendicular to the ground and by using a ruler, so that the distance between the udder base and the teat end was calculated. The teat diameter was measured at the mid-point of each teat by using callipers. The distances between teats, including the distances between the fore teats, fore and rear teats (the distance between the right fore and right rear teats) and rear teats, were measured at the mid-point of teats by using a tape measure. The heights of the right fore and right rear teats were measured between the teat end and the ground.

Udder form: Udder form is classified under 4 groups, including trough-shaped, ball-shaped, rear-heavy and pendulous udders. Udder morphology was evaluated as described below (Uzmay *et al*., 2003). Mammary structures characterized with an udder base both strongly attached to the abdominal wall and in parallel position with the ground, the fore udder extending towards the abdomen and when inspected laterally, the rear udder localized behind the rear legs, forming a well proportioned and marked protrusion, as well as teats extending at the most to the level of the hock (anatomically the ankle) were evaluated as trough-shaped udders. Mammary structures, resembling a hemisphere when inspected laterally, with a relatively narrow perimeter of udder attachment to the abdominal wall and fore and rear udder lobes of approximately equal capacity, as well as teat lengths extending at the most to the mid-hock were recorded as ball-shaped udders. Furthermore, mammary structures with a fore udder base situated 3-4 fingers higher than the rear udder base when inspected laterally and thereby displaying an unbalanced teat placement were evaluated as rear-heavy udders. Lastly, mammary structures with an excessively long central ligament, a narrow upper part and a relatively wide lower part (resembling the shape of a bag) pendulating sideways excessively during the movement of the animal and which have teats extending below the hock level were evaluated and recorded as pendulous udders.

Teat end shape: Teat end shapes were classified as pointed, round, flat, disk, inverted, pointed disk, round flat and round ring (Seykora and McDaniel, 1985).

Evaluation of data: Due to the SCC not displaying a normal distribution, data of SCC were log transformed to base 10.

Due to the lactation stage being determined to have effect on log SCC, residuals were calculated, by means of the regression analysis method, for log SCC and udder and teat measures. The parametric linear correlation technique (Pearson correlation) was used for the determination of coefficients of correlation between udder and teat measures and log SCC. The relationships between udder and teat measures and log SCC were determined by using the multiple linear regression model and all parameters were included in the model in step 1. In the last step, the best regression model was determined by using the backward approach. The effects of the teat end shape, udder form and localization of udder lobes on log SCC were assessed by using the linear model is given:

$$y_{ijk} = \mu + a_i + b_j + c_k + e_{ijkl}$$

- y_{ijk} = Log SCC with normal distribution
- μ = Population mean
- a_i = Effect of teat end shape (pointed, round, flat, disk, inverted, pointed disk, round flat and round ring)
- b_j = Effect of udder form (ball-shaped, rear-heavy, trough-shaped and pendulous)
- c_k = Effect of localization of udder lobe (fore right lobe, fore left lobe, rear right lobe and rear left lobe)
- e_{ijkl} = Effect of experimental error

RESULTS AND DISCUSSION

Means and standard deviations for log SCC and udder and teat measures of dairy cows are presented in Table 1 and percentage distributions of teat end shape, udder form and localization of udder lobes are given in Table 2.

Stage of lactation was determined to have effect on log SCC ($p<0.01$). Mean squares and squared multiple correlation coefficients for lactation stage are presented in Table 3.

Table 1: Means and standard deviations for log SCC and udder and teat measures

Traits	N	Mean	SD
Log SCC	480	5.73	0.39
Teat length (cm)	480	5.88	0.05
Teat diameter (cm)	480	2.23	0.01
Front teat distance (cm)	480	14.06	0.16
Front-rear teat distance (right side) (cm)	480	9.56	0.10
Rear teat distance (cm)	480	8.16	0.11
Front udder height (cm)	480	54.92	0.29
Rear udder height (cm)	480	54.30	0.31

Table 2: Percentage distributions of teat end shape, udder form and localization of udder lobes

	Traits	Observation	(%)
Teatend shape	Pointed	58	12.3
	Round	189	40.2
	Flat	95	20.2
	Disk	24	5.1
	Inverted	52	11.1
	Pointed disk	29	6.2
	Round flat	11	2.3
	Round ring	12	2.6
Udder form	Ball	205	43.6
	Rear-heavy	95	20.2
	Trough	146	31.1
	pendulous	24	5.1
Udder lope	Front right teat	122	26.0
	Front left teat	119	25.3
	Rear right teat	120	25.5
	Rear left teat	109	23.2

Table 3: Mean squares and multiple squared correlation coefficients (R^2) for lactation stage

	df	Log SCC
No. of lactation	1	6.731
Residual	480	0.135
R^2		0.300

Table 4: Percentage correlations of unadjusted (R) and residual (r^1) log SCC values with measures

Traits	R	r^1
Teat length (cm)	10.9*	2.4
Teat diameter (cm)	13.8**	4.6
Front teat distance (cm)	1.5	4.3
Front +rear teat distance (right side) (cm)	0.1	9.2*
Rear teat distance (cm)	8.8	0.6
Front udder height (cm)	-12.4**	3.8
Rear udder height (cm)	-12.3**	5.5

**: p<0.01; *: p<0.05

Percentage correlations of unadjusted and residual log SCC values with measures are given in Table 4. Adjusted data were determined to be smaller than residual data. Therefore, stage of lactation was determined to have effect on log SCC and udder and teat measures, respectively. The correlation coefficients of residual data were found to be small. The correlation between log SCC and fore-rear teats was determined to be positive and statistically significant ($p<0.05$).

Residual linear regression coefficients from regression analyses for log SCC and udder and teat measures, according to stage of lactation are presented in Table 5. Squared multiple correlation values (R^2) were found to be small (0.08 and 0.17). All udder and teat measures were included in step 1 of the multiple linear regression analysis. The relationship between teat diameter, fore teat height and rear teat height was determined to be statistically significant ($p<0.05$). According to the results of analyses performed by using the backward approach for the determination of the best model, only teat diameter and fore teat height were determined to be statistically significant ($p<0.05$).

Table 5: Residual linear regression coefficients from regression analyses for log SCC from objective udder and teat measures

Step 1	b
Teat length (cm)	0.08
Teat diameter (cm)	0.17*
Front teat distance (cm)	-0.09
Front-rear teat distance (right side) (cm)	-0.03
Rear teat distance (cm)	0.02
Front udder height (cm)	-0.17*
Rear udder height (cm)	0.08*
Step last	
Teat diameter (cm)	0.11*
Rear udder height (cm)	-0.14*

All objective measures were used in step 1, but in step last, analysis were used only significant measures included with backward approach

The results of analyses of variance aimed at the determination of the influence of teat end shape, udder form and localization of udder lobes on log SCC are presented in Table 6. The difference between log SCC means with respect to teat end shape was determined to be statistically significant ($p<0.05$). The effects of udder form and udder lobe localization on log SCC were found to be statistically insignificant ($p>0.05$). The highest log SCC value was determined for the inverted teat end.

Despite the calculation of higher log SCC values in dairy cows with pendulous udders, the difference between the mean log SCC values of udder forms was found to be statistically insignificant.

Mean log SCC values with respect to udder lobe localization were determined not to display any statistical difference ($p>0.05$).

Based on the evaluation of the results of the present study, regression coefficients pertaining to teat length were determined to be positive, yet small and statistically insignificant ($p>0.05$). Similar results have been reported previously (Kuczaj, 2003). However, Shook (1989) reported that cows showed predisposition to mastitis with increasing in teat length mastitis incidence increased therefore, it was underlined that SCC also increased in the milk of the cows.

Squared multiple correlation (R^2) values pertaining to teat diameter were found to be positive, yet small and statistically significant ($p<0.05$). The result pointing out to increase in the incidence of mastitis cases with increase in teat diameter is consistent with many literature reports (Hickman, 1964; Thomas *et al*., 1984; Chrystal *et al*., 1999;

Table 6: Results of analyses of variance for the influence of udder and teat traits, evaluated by using subjective measures, on log SCC

Traits		N	Mean	SE	Minimum-maximum
Teat end shape	Pointed	58	5.68[b]	0.05	5.57-5.78
	Round	189	5.74[ab]	0.03	5.67-5.80
	Flat	95	5.73[ab]	0.04	5.64-5.81
	Disk	24	5.63[b]	0.08	5.47-5.79
	Inverted	52	5.90[a]	0.06	5.79-6.01
	Pointed disk	29	5.79[ab]	0.07	5.65-5.93
	Round flat	11	5.68[b]	0.12	5.46-5.91
	Round ring	12	5.75[ab]	0.11	5.53-5.96
Significance*					
Udder form	Ball	205	5.69	0.03	5.63-5.76
	Rear-heavy	95	5.76	0.05	5.67-5.85
	Trough	146	5.69	0.04	5.62-5.76
	Pendulous	24	5.80	0.08	5.64-5.96
Significance[ns]					
Udder lope localization	Front right lope	122	5.76	0.04	5.68-5.84
	Front left lope	119	5.71	0.04	5.63-5.80
	Rear right lope	120	5.68	0.04	5.60-5.77
	Rear left lope	109	5.79	0.04	5.70-5.88
Significance[ns]					

Values having different letters are different significantly ($p<0.05$); ns: non significant

Kuczaj, 2003; Coban *et al*., 2007). The most significant cause of intramammary infections is the entrance of microorganisms into the mammary duct. The anatomical structure of the teat duct either facilitates or complicates the entrance of microorganisms (Appleman, 1973). This, in turn, suggests the increase of disposition to mastitis with an increase in the diameter of the teat duct.

As can be seen in Table 5, the squared multiple correlation values (R^2) c alculated between the distance between teats and log SCC were small and statistically insignificant ($p>0.05$). Similarly, Kuczaj (2003) determined the correlation coefficients between SCC and the distance between teats to be small. Furthermore, only the distance between the rear teats was found to be statistically significant by this author. In another study, disposition to mastitis was concluded to decrease with reduced distances between teats (Thomas *et al*., 1984).

In the present study, the regression coefficient pertaining to fore teat height was determined to be negative and statistically significant. Similar results have been reported by many authors (Seykora and McDaniel, 1985; Rogers *et al*., 1991). The relationship between rear teat height and log SCC was demonstrated to be statistically insignificant.

The results of analyses of variance for the effects of teat end shape, udder form and udder lobe localization on log SCC demonstrated the differences between teat end shape means to be statistically significant ($p<0.05$). The highest log SCC value was determined for inverted teats. Appleman (1973), as a result of his study in which teat end shapes have been classified differently, determined teat end shape to have effect on SCC. In a study, in which the same classification method used in the present study, was utilised, similarly, dairy cows with inverted teats were determined to be more susceptible to mastitis (Seykora and McDaniel, 1985).

In the present study, the influence of udder form on SCC was determined to be insignificant. However, in previous studies, disposition to mastitis and thereby SCC were determined to be increased in pendulous udders (Seykora and McDaniel, 1985; Uzmay *et al*., 2003). The statistical insignificance of the influence of udder form, determined in the present study, may be related to the frequency of pendulous udder form being low.

The localization of udder lobes being determined to have no effect on SCC is consistent with the results of previous studies (Seker *et al*., 2000). However, Batra *et al*. (1977) reported that mastitis to be encountered more frequently in fore udder lobes when compared to rear udder lobes. On the contrary, some researchers have pointed out to the determination of higher SCC values in rear udder lobes (Barkema *et al*., 1997). Therefore, a consensus has not been able to be reached on the influence of udder lobe localization on SCC.

CONCLUSION

SCC, udder and teat traits classified by using objective measures were determined to be affected by the stage of lactation. Therefore, the necessity for the elimination of the influence of lactation stage in future studies has emerged. By means of reducing the frequency of low fore teat height and large teat diameter through hygiene, mastitis treatment and milking techniques, the incidence of mastitis cases can be reduced. Furthermore, teat end shape was demonstrated to be influential on SCC. However, in order to be able to use teat end shape as a criterion for the breeding of animals less susceptible to mastitis, it is considered that the repeatability and heritability of teat end shape should be calculated.

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