Animal Review
2015 Vol. 2, No. 2, pp. 58-67
ISSN(e): 2409-6490
ISSN(p): 2412-3382
DOI: 10.18488/journal.ar/2015.2.2/101.2.58.67

CORRELATION BETWEEN MILK YIELD, SOMATIC CELL COUNT AND MILK QUALITY IN DAIRY FARMING

Ferhan Kaygısız[1]* --- Gürhan Çiftçioğlu[2] --- Gülhan H. Türkay[3] --- Yavuz Cevger[4] --- Ghassan Issa[5] --- Hülya Yalçıntan[6] --- Hasret Yardibi[7]

[1,6]*Istanbul University, Faculty of Veterinary Medicine, Animal Husbandry Department, Avcılar, İstanbul, Turkey*

[2,5]*Istanbul University, Faculty of Veterinary Medicine, Food Hygiene and Technology Department ,Avcılar, İstanbul, Turkey*

[3,7]*Istanbul University, Faculty of Veterinary Medicine, Biochemistry Department, Avcılar, İstanbul, Turkey*

[4]*Ankara University, Faculty of Veterinary Medicine, Animal Health Economics and Management Department, Dışkapı, Ankara, Turkey*

ABSTRACT

This study investigated between milk yield and Somatic Cell Count, sampled from 3 different dairy enterprises. Chemical and microbiological parameters analyzed for the relation with milk yield. Milk samples have been collected from 10 dairy cows, two times per month during 1 year period. Bacteriological analyzes have been employed for milks. Milk yield data for each cow have been recorded in every sampling day. Depending on the logistic regretion analyses on the data collected from all enterprises; high total plate count and E.coli counts have negative effects on milk yield, but has been found significally important ($p<0.05$) only for the data of E.coli. counts. In group 1; somatic cell count and E.coli counts have negative effect on milk yield and only the data of E.coli has been found statistically important ($p<0.05$). In group 2; only the data related negative effect of E.coli counts on milk yield has been found as statistically important ($p<0.05$). The third group, total plate count has negative effect on milk yield. Regarding to the chemical analyses of fat in milk, non-fat dry matter, density and protein values have been detected in the enterprises 1, 2 and 3 as 2.88, 3.56, 4.34; 7.91, 7.83, 8.12; 1026.4, 1025.8, 1026; 3.04, 2.96, 3.07, respectively. According to the correlation analyses applied between milk yield and fat in milk, non fat-dry matter, protein and density in milk in all enterprises; there were significant correlation between non-fat dry matter and milk yield in enterprise 2 ($p<0.05$) and density and milk yield in enterprise 3 ($p<0.01$).

Keywords: Cow, Raw milk, Milk yield, Milk quality, Somatic cell counts, Biochemical parameters.

Received: 26 November 2014/ **Revised:** 3 April 2015/ **Accepted:** 7 April 2015/ **Published:** 10 April 2015

† Corresponding author

Contribution/ Originality

The study contributes the existing literature, which the correlation between SCC and the microbiological milk quality has been compared, in order to analize the possible effects on the production of dairy products and the reflection for dairy industry.

1. INTRODUCTION

Milk quality can have a significant impact on milk processing efficiency and product quality and encompasses factors relating to composition, udder health and hygiene [1].

Udder health and somatic cell count (SCC) are among the most important criteria in evaluating the quality of milk produced and herd management, in the countries where animal husbandry is developed [2, 3]. The negative relationship between SCC and milk yield is commonly used in estimating the financial losses related to mastitis in dairy cattle plants. These estimates guide for studies regarding the control and prevention of mastitis [4-7].

The European Union (EU) has banned the consumption of milk, of which bulk tank SCC (BTSCC) excesses the value of 400.000 cell/ml., since 1998. This limit is set in Turkish Food Codex as 500.000 cell/ml. It became obligatory for the milk producers in Turkey which carries out EU integration procedures to take the necessary measures regarding mastitis in order to increase operational profitability and to ensure the milk hygiene.

The aim of the present study is to determine the relationship between SCC and milk yield in three intensive plants and to explore the current situation in terms of recent quality of milk produced.

2. MATERIALS AND METHODS

30 cows in three different intensive plants were used as animal materials in the present study. Milk samples were taken from each udder lobe of 10 cows in each plant two times a month during one year. Charm Firefly, FF-FT-CARRY-CS model ATP Bioluminescence Somatic Cell count device and SCC kits were used for SCC determination. The milk composition analyses, fat, fat-free dry matter, density and protein analyses were performed by using the Milkana Ultrasonic Milk Analyser (Ekomilk EON TRADING LLÇ USA). After the SCC analysis of the milks obtained from dairy cattle, microbiological analyses were employed for milks, which were over the limit of 500.000 cell/ml stated in the Turkish Food Codex [8] and therefore found to be unsuitable for consumption. The raw milk samples brought to the laboratory were subjected to microbiological analyses in terms of total number of aerobic mesophylic bacteria (TMC), generic *Escherichia coli* (*E.coli*) and *Staphylococcus aureus* (*S.aureus*) counts. For microbiological analyses, Serial decimal dilutions were prepared up to stage (1/10) 10^7 from main dilution of 10 ml milk sample / 90 ml phosphate buffer solution [9] and 1 ml from these dilutions were applied into appropriate 3M sterile petrifilms in duplicates. Petrifilm aerobic count plates (3M, 06400) were used in order to determine Total Aerobic Mesophylic Bacteria Count (TMC). Petrifilms were inoculated and incubated at 32±1°C degree for 48±1 hours. The aerobic count plates were evaluated at the end of the incubation period [10]. Petrifilm *E.coli*/Coliform plates (3M, 06404) were used in order to

determine the number of coliform – *E.coli* bacteria. Petrifilms were inoculated and incubated at 35°C degree for 24±2 hours. The coliform – *E.coli* bacteria count plates were evaluated at the end of the incubation period [11]. Petrifilm *S. aureus* count plates (3M, 06490) were used in order to determine the number of *S. aureus*. Petrifilms were inoculated and incubated at 37±1°C degree for 48±1 hours. Biochemical identification tests were performed via the application of *S.aureus* discs on positive colonies at the end of the incubation period [12]. Additionally, the data about the daily milk efficiency, the number of lactation on the date when the milk samples were taken and about lactation period were recorded.

In order to determine the relationship between SCC, milk yield, TMC, *E.coli* and *S.aureus* counts, the "logistic regression model" was used as a method of data analysis [13]. To this end, the variable milk yield (MY) was categorized into two groups based on intra-group average milk yield: "below the group average" and "above the group average". It was included in the created regression equation under two categories as "low" and "high". Due to the heterogeneous structure of the independent variables, these variables were included in the equation being logarithmically transformed. Accordingly, 4 independent variables, which are logscc, logtmc, logecoli and logsaureus, were used. A correlation analysis was performed in order to determine the relationship between milk yield and fat, fat-free dry matter, density and protein in milk.

3. RESULTS

3.1. Findings Related to the Relationship between Milk Yield and Milk Quality

Analyze results regarding to all enterprises have been given in Table 1.

Table-1. Logistic regression analysis results between milk yield and microbiological tests for all enterprises

Variables	B	Sx	Wald	df	Sig	Exp(B)
logscc	0.100	0.298	0.112	1	0.738	1.105
logtmc	-0.190	0.214	0.790	1	0.374	0.827
logecoli	-0.336	0.162	4.310	1	0.038	0.714
logsaureus	0.094	0.099	0.903	1	0.342	1.098
Constant	0.754	1.076	0.491	1	0.484	2.126

logscc: Logaritmic somatic cell counts, logtmc: Logaritmic total aerobic mesophylic bacteria, logecoli: Logaritmic generic *Escherichia coli*, logsaureus: Logaritmic *Staphylococcus aureus*
B: Regression coefficient, Sx: Standart error, Wald: B/Sx, df: Degree of freedom, Sig: Significant,
Exp: Odds Ratio

When Table 1 is analyzed, where the results of the logistic regression performed on the data of all enterprises were shown, it was seen that TMC and *E.coli* counts in milk have a negative effect on milk yield; however only the value of *E.coli* was statistically significant ($p<0.05$). Accordingly, a logarithmic increase of 1 unit in *E.coli* counts in milk was caused a 0.34% decrease in the total milk yield.

Table-2. Logistic regression analysis results between milk yield and microbiological tests for Enterprise 1

Variables	B	Sx	Wald	df	Sig	Exp(B)
logscc	-0.357	0.638	0.313	1	0.576	0.700
logtmc	0.207	0.420	0.243	1	0.622	1.231
logecoli	-0.823	0.323	6.500	1	0.011	0.439
logsaureus	0.083	0.184	0.202	1	0.653	1.086
Constant	1.093	2.259	0.234	1	0.629	2.983

logscc: Logaritmic somatic cell counts, logtmc: Logaritmic total aerobic mesophylic bacteria, logecoli: Logaritmic generic *Escherichia coli*, logsaureus: Logaritmic *Staphylococcus aureus*
B: Regression coefficient, Sx: Standart error, Wald: B/Sx, df: Degree of freedom, Sig: Significant,
Exp: Odds Ratio

When Table 2, which shows the logistic regression analysis results of the data of the 1st enterprise, was examined, it was seen that number of somatic cells and *E.coli* counts have a negative effect on milk yield; however, only the value of *E.coli* was statistically significant ($p<0.05$). Accordingly, a logarithmic increase of 1 unit in *E.coli* counts in milk was caused an 0.82% decrease in the total milk yield.

Table-3. Logistic regression analysis results between milk yield and microbiological tests for Enterprise 2

Variables	B	Sx	Wald	df	Sig	Exp(B)
logscc	0.433	0.618	0.491	1	0.483	1.543
logtmc	0.627	0.412	2.313	1	0.128	1.872
logecoli	-0.874	0.368	5.652	1	0.017	0.417
logsaureus	-0.041	0.224	0.033	1	0.856	0.960
Constat	-2.077	1.982	1.098	1	0.295	0.125

logscc: Logaritmic somatic cell counts, logtmc: Logaritmic total aerobic mesophylic bacteria, logecoli: Logaritmic generic *Escherichia coli*, logsaureus: Logaritmic *Staphylococcus aureus*
B: Regression coefficient, Sx: Standart error, Wald: B/Sx, df: Degree of freedom, Sig: Significant,
Exp: Odds Ratio

When Table 3, which shows the logistic regression analysis results of the data of the 2nd enterprise, was examined, it was seen that only the negative effect of *E.coli* counts on milk yield was statistically significant ($p<0.05$). Accordingly, a logarithmic increase of 1 unit in *E.coli* counts in milk was caused an 87% decrease in the total milk yield.

Table-4. Logistic regression analysis results between milk yield and microbiological tests for Enterprise 3

Variables	B	Sx	Wald	df	Sig	Exp(B)
logscc	0.546	0.470	1.347	1	0.246	1.726
logtmc	-0.787	0.427	3.394	1	0.065	0.455
logecoli	0.204	0.268	0.576	1	0.448	1.226
logsaureus	0.199	0.159	1.568	1	0.211	1.220
Constant	0.562	2.238	0.063	1	0.802	1.754

logscc: Logaritmic somatic cell counts, logtmc: Logaritmic total aerobic mesophylic bacteria, logecoli: Logaritmic generic *Escherichia coli*, logsaureus: Logaritmic *Staphylococcus aureus*
B: Regression coefficient, Sx: Standart error, Wald: B/Sx, df: Degree of freedom, Sig: Significant,
Exp: Odds Ratio

When Table 4, which shows the logistic regression analysis results of the data of the 3rd enterprise, was examined, it was seen that TMC has a negative effect on milk yield for this group; however, this effect was not statistically significant ($p<0.05$). Accordingly, a logarithmic increase of 1 unit in TMC in milk was caused a 79% decrease in the total milk yield although this value was not statistically significant.

3.2. The Findings of the Relationship between Milk Efficiency and Milk Components

The milk yield rates, the averages of some milk components and their standard deviations, belonging to the cattle in enterprises 1, 2 and 3, were given in Table 9. The lowest milk yield was observed in Enterprise 1, while the highest milk yield was observed in Enterprise 3. In parallel, the highest amount of fat and non-fat dry matter was observed in the milks of Enterprise 3. No statistically significant difference was found between the enterprises in terms of milk protein.

Table-5. Milk yield and milk compositions in Enterprise 1, 2 and 3

	Enterprise 1			Enterprise 2			Enterprise 3		
Parameters	n	X	Sx	n	X	Sx	n	X	Sx
Milk yield (kg/day)	103	16.00	±4.00	79	18.70	±2.95	97	22.64	±8.17
Fat (%)	72	2.88	±3.26	79	3.56	±3.43	85	4.34	±4.22
Non-fat dry matter (%)	86	7.91	±1.07	84	7.83	±1.02	87	8.12	±0.96
Dansity (g/ml)	88	1026.39	±8.69	80	1025.84	±6.20	99	1025.97	±6.57
Protein (%)	92	3.04	±0.41	92	2.96	±0.35	100	3.07	±0.43

When Table 6, which shows the results of the correlation analysis performed between the milk yield rates and milk components of Enterprise 1, was examined, it was seen that there was no statistically significant relationship between milk yield and milk components.

Table-6. Correlation analysis between milk yield and milk components belonging to Enterprise 1

Enterprise 1		Milk Yield	Fat	Non-fat dry matter	Dansity	Protein
Milk Yield kg/cow/day	Correlation Coefficient	1.000	.085	.32	.142	.022
	Significancy	-	.477	.774	.190	.839
	Total (n)	103	72	85	87	91
Fat (%)	Correlation Coefficient		1.000	.101	.134	.135
	Significancy		-	.399	.261	.257
	Total (n)		72	72	72	72
Non-fat dry matter (%)	Correlation Coefficient			1.000	.262(a)	.326(b)
	Significancy			-	.015	.002
	Total (n)			86	86	86
Dansity (g/ml)	Correlation Coefficient				1.000	.419(b)
	Significancy					.000
	Total (n)				88	88
Protein (%)	Correlation Coefficient					1.000
	Significancy					
	Total (n)					92

(a) $p<0.05$ (b) $p< 0.01$

Table-7. Correlation analysis between milk yield and milk components belonging to Enterprise 2

Enterprise 1		Milk Yield	Fat	Non-fat dry matter	Dansity	Protein
Milk Yield kg/cow/day	Correlation Coefficient Significancy Total (n)	1.000 - 79	.160 .163 78	.237[(a)] .035 79	.031 .784 79	.250 .026 79
Fat (%)	Correlation Coefficient Significancy Total (n)		1.000 - 79	.033 .773 79	.161 .158 79	.045 .692 79
Non-fat dry matter (%)	Correlation Coefficient Significancy Total (n)			1.000 - 84	.302[(b)] .006 80	.861[(b)] .000 83
Dansity (g/ml)	Correlation Coefficient Significancy Total (n)				1.000 80	.326[(b)] .003 80
Protein (%)	Correlation Coefficient Significancy Total (n)					1.000 - 83

[(a)]p<0.05 [(b)]p<0.01

When Table 7, which shows the results of the correlation analysis performed between the milk yield rates and milk components of Enterprise 2, was examined, it was seen that there was a positive and statistically significant relationship between milk yield and the amount of dry matter and protein in milk (p<0.05).

Table-8. Correlation analyze between milk yield and milk components belonging to Enterprise 3

Enterprise 1		Milk Yield	Fat	Non-fat dry matter	Dansity	Protein
Milk Yield kg/cow/day	Correlation Coefficient Significancy Total (n)	1.000 - 97	.142 .196 85	.136 .209 87	.327[(b)] .001 97	.146 .154 97
Fat (%)	Correlation Coefficient Significancy Total (n)		1.000 - 85	.023 .836 85	.130 .237 85	.012 .912 85
Non-fat dry matter (%)	Correlation Coefficient Significancy Total (n)			1.000 - 87	.197 .067 87	.283[(b)] .008 87
Dansity (g/ml)	Correlation Coefficient Significancy Total (n)				1.000 99	.173 .087 99
Protein (%)	Correlation Coefficient Significancy Total (n)					1.000 100

[(a)]p<0.05 [(b)]p<0.01

When Table 8, which shows the results of the correlation analysis performed between the milk yield rates and milk components of Enterprise 3, was examined, it was seen that there was a negative and statistically significant relationship between milk yield and milk density (p<0.01).

4. DISCUSSION

Regarding to the data obtained from 3 different enterprises and statistical analyzes during this research, it was not able to found a statistically significant relationship between milk yield and SCC. There are some studies in literature, in which the milk yield losses in cows with subclinical mastitis are determined based on the relationship between milk yield and SCC [14-17]. The milk yield losses were reported between 5.6 and 11.9 kg at 3 million cell/ml SCC level, which is accepted as an advanced subclinical mastitis. In another study [18], it was stated that the decrease in milk yield up to SCC rate of 500.000 cell/ml was not statistically significant. In this present study, as a result of the analyses performed for each enterprises, TMC and *E.coli* counts were found to have a negative effect on milk yield; however, only the value of *E.coli* was statistically significant ($p<0.05$). Accordingly, 1 unit logarithmic increase of *E.coli* counts in milk was caused a 0.34% decrease in the total milk yield. It was statistically exposed that there would be a decrease in milk yield in subclinical mastitis cases which may be related to *E.coli*. Among the analysed 252 milk samples, *E.coli* was found to be higher than 10 cfu/ml. *E.coli* is one of the major pathogens causing subclinical mastitis and it causes SCC to increase. In a study [19] , it was reported that *E.coli* was isolated in 4.8% of the infected udder lobes in milk samples, while in another study [17] reported that they isolated *E.coli* in 54% of the infected milk samples and SCC reached the value of 800.000 - 1.000.000 cell/ml in the milks where *E.coli* grew. The number of somatic cells in milk depends on many factors such as infection status of milk, the number of infected udder lobes, age of cattle, the number of lactation, seasonal conditions, techniques used and management conditions [20].

When the results of the analysis performed on the data of Enterprise 1 are analyzed, SCC was found to have a negative effect on milk yield but this effect was not statistically significant. No statistically significant effect of SCC on milk yield was found in Enterprises 2 and 3. According to the data analyses, it was agreed that the number of animals used in the present study was not sufficient to work with statistical data; therefore, it would be appropriate to use a higher number of experimental animals in the future studies.

The average values of milk yield, milk fat, non-fat dry matter, density and protein of the milk samples taken from three different enterprises are given in Table 9. The parameters of milk components analyzed in the present research were within the change interval developing with various effects. These limits were reported to be 2.5-6% for milk fat, 8-9% for non-fat dry matter and 2.9-5% for protein[21]. When the milk fat values given in the table were analyzed, the rate of milk fat was found to be within the change interval in Enterprise 1, while this rate was found to be lower compared to Enterprises 2 and 3. It is known that the rate of fat in milk varies depending on the race of cattle, the content and the amount of the consumed feed and also seasonal changes are observed [21, 22]. It is suggested that mastitis affects the content of milk and changes the rate of fat in milk [23]. A lower rate of fat in milk in Enterprise 1 shows that the number of cows with mastitis is higher in this enterprise.

When the amount of non-fat dry matter in the milk samples taken from the plants was analysed, it was seen that this amount was below the change limits in Enterprises 1 and 2, while it was within usual limits in Enterprise 3. It is also known that the amount of non-fat dry matter varies depending on seasons and feed and it is related to milk amount and decreases due to mastitis [24]. The average milk densities in the three plants from which the milk samples were taken were found to be lower than the density values reported in literature [21]. It is reported that milk density changes depending on all the matters comprising milk [25]. When the milk samples taken from the plants were evaluated in terms of protein values, no statistically significant difference was found among the enterprises. It is known that changes in the rate of milk protein are not as common as the changes in milk fat [22] and milk protein was observed to be at lower limits in each enterprise. As the mastitis bacteria cause damages on udder gland cells and therefore cause a decrease in protein, fat and milk sugar synthesis, they negatively affect milk yield and quality [26]. Although no statistically significant differences were observed among the amounts of fat, non-fat dry matter, density and protein in the milk samples analyzed in the present research, the parameters were found to be at the lower limits of the usual values.

A correlation analysis was performed in order to determine the relationship between milk efficiency and fat, non-fat dry matter, density and protein in milk in each enterprise. A positive and statistically significant relationship was found between milk yield and the amount of dry matter and protein in milk ($p<0.05$) in Enterprise 2, while there was a statistically significant relationship between milk yield and density ($p<0.01$) in Enterprise 3.

5. CONCLUSIONS

The findings of the present study show that the subclinical mastitis cases, which may occur in dairy plants, may cause not only losses in milk yield but also decreases the chemical quality of milk. This strengthens the idea that the financial losses encountered especially in bacterial mastitis are related to the reduced technological quality of milk as well as reduced milk yield. Given that a high rate of microbiological load to be observed in milk pose a risk for public health as well, early diagnosis of mastitis in dairy plants and steps to prevent mastitis are of great importance.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Contributors/Acknowledgement: This study was supported by Research Fund of Istanbul University. Project number: 1199. The authors also would like to thank Kaan Göksal and İlker Çoban for their assistance.

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