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Somatic cells count in milk – indicator of milk quality and health of cows

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ABSTRACT

In years 2000 and 2001 on 4 farms with total number of 1100 cows of the Friesian breed and annual production of approx. 8 thousand tons of market milk in defined region the influence of farm and management factors, year season and studied years on the somatic cells count in stable (tank bulk) milk samples (SCCss) and samples of milk of individual cows (SCCis) was analysed. There were calculated the correlations between the somatic cells count and the number of treated cases of mastitis, between somatic cells and milk quantity and between milk quantity and the number of treated cases of mastitis. In the studied years there was on average SCCss (n=271) 328.2x10^3/ml of milk (LSCCss is 5.51±0.08/ml), and on average SCCis (n=21942) 448.8x10^3/ml of milk (LSCCis is 5.24/ml). On SCCss of milk there was statistically highly significant influence of years (F=41.76, P≤0.0001), farm (F=25.44, P≤0.0001), and not of the season (F=0.36, P=0.547). On SCCis of milk there was, however, statistically highly significant (P≤ 0.0001) influence of all three factors, i.e. years (F=904.19), season (F=47.92) and farm (F=20.94). Year and season had no statistically significant influence on manifestation of mastitis (F=0.30, P=0.587 and F=0.91, P=0.344), while statistically highly significant was the influence of the farm (F=26.81, P≤0.0001). Between SCCis of milk and number of treated cases of mastitis there is statistically significant correlation (r=0.275, P≤0.008), between number of cases of mastitis and milk quantity the correlation is r=0.332, P≤0.001, and between milk quantity and SCCss the correlation is r=-0.289, P≤0.006. The correlation between SCCss of milk and SCCis of milk (r=0.608, P≤0.0001) is statistically highly significant.
(Keywords: milk, stable (tank bulk) and individual samples, somatic cells)

INTRODUCTION

Somatic cells in milk are important for the breeder of milk cows from the point of view of the breeding economy. In countries with developed milk production as well as in our country the somatic cells count in stable (tank bulk) is one of the parametres of the milk purchase price (Off. J. of the EC, 1992, No L. 268/17; Regulations on determination of the purchase price of cow milk, Ur.list. RS, 1993/23 and Regulations on elements for formation of the purchase price of cow milk, Ur.list. RS, 107/22.12.2001). The somatic cells are, therefore, indicator of milk quality from the point of view of its hygienic and technological characteristics. They are determined at least once a month. *Schukken* (1992) states that a monthly somatic cells count in delivered milk in ideal conditions should not exceed 200 to 300x10^3/ml.

According to the somatic cells count also the health of cows, especially the health of udders, is evaluated. Milk from healthy udder usually does not exceed $200x10^3$ cells/ml (*Edmondson*,1998), normally it is even lower (*Smith* and *Hogan*, 1999; *Malinovski*, 2001). *Rabold et al*. (1992) states that in milk from healthy udder or in milk form healthy quarter in normal lactation the somatic cells count is even lower than $100x10^3$/ml, and the somatic cells count which is higher than $250x10^3$/ml shows disturbances in one or more udder quarters. The somatic cells count between $200x10^3$ and $300x10^3$/ml milk shows that the cow was infected recently (*Smith*, 1996). The increased somatic cells count in milk of individual cows is, therefore, a reliable indicator of damages of udder tissue. However, *Edmondson* (1998) points out that results of the somatic cells count measurements in individual cows are not the most effective way for solving the mastitis problems, therefore before taking measures we must have more consecutive estimations. In Slovenia the somatic cells in milk of individual cows are being determined monthly for all milk cows only in some herds.

The somatic cells count in milk is also very important for the evaluation of the balance of cow nutrition. Deficiencies in nutrition of cows (deficiency or surplus of determined nutritive substances and mineral, especially trace elements, too great share of concentrates, spoilt fodder, sudden change of ration) influence the too great burdening and irritation of mammary (lacteal) gland and increased somatic cells count in milk. The nutrition influences also on the resisitivity of cows to masititis. *Erskine* (1993) and *Hogan et al.* (1993) report that the deficiency of the vitamin E and selenium in ration is connected with greater frequency of environmental intrammamary infections and clinical cases of mastitis. *Foltys et al*. (2001) attained statistically significant ($P \leq 0.001$) reduction of somatic cells count in milk at addition of 0.2 ppm of organic selenium to fodder mixture for cows and which was given to cows during 8 weeks. Important nutrition components are also vitamin A and beta-carotene, and among minerals copper and zinc (*Hogan et al*., 1996).

The somatic cells in milk can also be used as a selection criterion for increasing resistivity of cows to mastitis. *Philipsson et al*. (1993) have determined for the Scandinavian countries positive correlation ($r=0.10$) between somatic cells count in milk and morbidity rate of cows with mastitis. The same author et al. (1995) quote that in Sweden on sample of 750 thousand cows, daughters of 1462 red-white and 911 Friesian bulls between relative breed value of clinical mastitis and of cells in milk were stated the correlation 0.45 in red-white and 0.41 in Friesian breed, and value of the genetic correlation 0.79 and 0.71 respectively. *Reents* (1997) quotes the genetic connection between somatic cells and manifestation of mastitis about 0.6 to 0.7. The evaluations of authors show that it is possible to increase the resistivity of cows to morbidity rate of mastitis by selection.

Up to now in Slovenia only the selection with regard to milk production is being performed, while the selection with regard to resistivity of cows to mastitis is still not being performed. By increased milkiness also sensitivity of cows to mastitis is being increased. *Solbu* (1989) states that with such one-sided selection the increased share of mastitis cases by 1.3% in a generation. *Pogačar* (1996 a, 1996 b) quotes that the one-sided selection in Slovenia caused greater frequency of cow morbidity rate of mastitis in some lines and bulls which is being yearly increased. Mastitis to many breeders causes great losses since it usually involves the best milk cows. Therefore, mastitis represent not only medical but also economic problem in production of quality milk.

Reents (1997) states that the causes for the increased somatic cells count in milk are most frequently the environmental factors which cannot be eliminated. Consequetly, the measures in curing mastitis must comprise the environmental factors as also the correction of the made mistakes. And these measures include particularly the zoo-hygienic conditions in the stable and milking place, faultless milking machine, milking procedures, hygienic

measures after milking, timely drying of cows, timely elimination of uncurable cows, balanced nutrition. At discovering of causes we must take into consideration also factors suc as age of cows, lactation stage, fertility, calving season, general condition of the herd. On four farms with milk cows from defined region the somatic cells have been defined for many years beside in stable (tank bulk) samples also in milk samples of individual cows within the regulara monthly control (AP). Mastitis remains the greatest economic, technological and sanitary problem on bigger farms. Our research goal was to study the influence of environmental factors: farm, season and studied years on somatic cells count in milk stable samples and milk samples of individual cows. We were also interested in differences among separate influences and correlations among them.

MATERIALS AND METHODS

In years 2000 and 2001 on 4 farms with total number of approx. 1100 cows of the Friesian breed the somatic cells count in samples of milk of individual cows (SCCis) and stable (tank bulk) milk samples (SCCss) was analysed. For the somatic cells count in milk of individual cows were used the data from regular AP control we received from experts (technical service) of the Slovene Agricultural Institute. For determination of the somatic cells count in stable samples the milk samples from tank were taken 1 to 4 times per month on each farm. Only on the farm B the somatic cells in milk of individual cows were not determined from June to September in the year 2000. A the same time the tank milk samples were used for commercial purposes. In two years there were in total analyzed 21942 milk samples of individual cows and 271 stable samples. All samples include evening and morning milking. At sample taking the daily quantity of milk in tank oscillated between 3500 and 9000 kgs. Production of milk for market was 8 288 tons in 2000 and 7 976 tons in 2001.

All 4 studied farms are in the defined region. Technology of breeding and nutrition of cows are the same on all four farms. Breeding is free, and nutrition differs among seasons. In summer (May-September) cows were pastured, and hay, maize and/or grass silage, appropriate fodder mixtures and mineral-vitamin supplement were given to them. Winter ration comprised hay, grass and maize silage, fodder mixtures and mineral-vitamin supplement.

On farms cows sick with mastitis were recorded and cured daily.

Milk analyses were performed in the laboratory of the Dairy Institute of Biotechnical Faculty, Department of Zootechnics. The somatic cells count in millilitre of milk was defined with the instrumental method with apparatus Fossomatic 90 (Foss Electric).

The analysis results were statistically processed with the programme package SAS/STAT (1994). The influence of the farm, years and season on the somatic cells count in milk was analysed with F-test (analysis of variance), while differences among years, seasons and farms were evaluated with Scheffe's test. The correlation between somatic cells count and number of cases of cured mastitis, milk quantity and number of cured cases of mastitis and milk quantity and somatic cells count in milk was calculated. Since the distribution of somatic cells count in milk samples of individual cows strongly deviates from normal, logarithms of basic measurements were calculated (LSCC). Based on these data the analysis of variance was performed afterwards.

RESULTS AND DISCUSSION

In *Tables 1* and *3* are shown the annual mean of the somatic cells count in stable (tank bulk) milk samples and the mean of milk samples of individual cows per farm with some statistical indicators, and in *Tables 2* and *4* the differences of studied influences (Scheffe's test).

Table 1

The mean SCCss (10^3/ml) and LSCCss in years 2000 and 2001 per farm with some statistical indicators

Farm	Year	No. of samples	Mean	Medi-ana	Stand. deviat.	Coef. var. %	Min.	Max.
A	2000	35	385.1	386.0	72.9	18.9	218.0	625.0
	LSCCss		5.58	5.59	0.08		5.34	5.80
	2001	33	364.4	350.0	54.8	15.0	270.0	476.0
	LSCCss		5.56	5.54	0.06		5.43	5.68
B	2000	35	302.8	302.0	52.1	17.2	201.0	406.0
	LSCCss		5.47	5.48	0.08		5.30	5.61
	2001	33	354.8	372.0	43.1	12.1	258.0	436.0
	LSCCss		5.55	5.57	0.06		5.41	5.64
C	2000	34	275.5	272.0	36.4	13.2	190.0	345.0
	LSCCss		5.44	5.43	0.06		5.28	5.54
	2001	34	334.6	332.5	45.9	13.7	226.0	469.0
	LSCCss		5.52	5.52	0.06		5.35	5.67
D	2000	34	275.3	268.0	47.0	17.1	205.0	376.0
	LSCCss		5.43	5.43	0.07		5.31	5.57
	2001	33	334.6	335.0	42.6	12.7	246.0	433.0
	LSSCss		5.52	5.52	0.06		5.39	5.63
A+B + C+D	2000	138	310.2	302.5	69.95	22.55	190.0	625.0
	LSSCss		5.48	5.48	0.09		5.28	5.80
	2001	133	347.0	345.0	48.09	13.86	226.0	476.0
	LSSCss		5.54	5.54	0.06		5.35	5.68
TOTAL	2000 and 2001	271	328.2	327.0	62.87	19.16	190.0	625.0
	LSCCss		5.51	5.51	0.08		5.28	5.80

Farm influence *F-value=25.44* *P≤0.0001*
Season influence *F-value=0.36* *P=0.547*
Year influence *F-value=41.76* *P≤0.0001*

The somatic cells count in joint (stable, tank bulk) milk samples is, especially in EU, used as indicator of hygienic conditions in milk production (*Heeschen et al*., 1997).

Numerous researches show that the somatic cells count over 250x10^3/ml milk represents for the breeder a serious warning that there are more cows with udder inflammation in herd. According to *Edmondson* (1998) in somatic cells count in tank bulk sample between 200 do 400x10^3/ml of milk in stable the infection is present, and with greater somatic cells count of 400x10^3/ml there is a problem of infectious mastitis in herd.

From *Table 1* is evident that the somatic cells count in stable sample in studied farms ranges from minimum 190.0x10^3/ml to maximum 625.0x10^3/ml of milk. The mean for both years is 328.2x10^3/ml of milk, and LSCCss is 5.51/ml, while mediana is 327.0x10^3. In year 2000 they were lower, 310.2x10^3/ml cells/ml, while the mean for the year 2001 was higher, 347.0x10^3/ml, being by 11.9% higher. In both years the greatest somatic cells count in stable milk samples was on farm A (385.0x10^3 in year 2000, 364.4x10^3/ml of milk respectively in year 2001), farm B is the following, while farms C and D are practically equal. However, on farm A the somatic cells count/ml of milk was

in the year 2001 (abs.) smaller than in the year 2000, while on other three farms it was increased in the year 2001.

Considering the summer (May-September) and winter (October-April) season in the year 2000 there were more somatic cells in milk in the summer season. The mean was $299.6x10^3$ cells/ml, and LSCCss was 5.48/ml, and in winter season $320.5x10^3$/ml, LSCCss was 5.51/ml. In opposition to the year 2000 there were in the year 2001 more somatic cells in milk in summer season, i.e. $354.3x10^3$/ml, LSCCss was 5.75/ml as in winter season where cells were $340.5x10^3$/ml, LSCCss was 5.53/ml. In the year 1995 on studied farms in summer season the somatic cells were $310x10^3$/ml, and in winter season $313.2x10^3$/ml, i.e. without greater difference between seasons (*Rajčevič* and *Jazbec*, 1997). Some sources quote that in summer season there were more somatic cells in milk than in winter, but not on pasture, although also the pasture conditions can contribute to manifestations of environmental mastitis.

In the year 1995 on same farms in stable milk samples (n=104) the somatic cells were $357.0x10^3$/ml (*Rajčevič et al*., 1996), in the year 1996 (geom.mean) $293.9x10^3$/ml (n=96) and in the year 1997 (geom. mean) $318.5x10^3$/ml (n=96) (*Rajčevič et al*.,1998). Presented results show considerable oscillation of somatic cells count in stable milk samples in mentioned years, of which the year 2001 was the worst as there were most cells in millilitre of milk, and the least cells were found in the year 1996.

With regard to the Regulations on elements for formation of purchase price for cow milk (Ur.list. RS 107/22.12.2001), and standard EU of 1.1.1998 on studied farms the 91.7% delivered milk in the year 2000 and 89.5% in the year 2001 contained the somatic cells up to $400x10^3$/ml, and in 8.3% and 10.5% milk the somatic cells were more than $400x10^3$/ml. In 1996 on the same farms in stable samples there was more than $400x10^3$ cells/ml in 7.3% milk, and in 1997 in 21.15% milk. Regarding the share of delivered milk with somatic cells count more than $400x10^3$/ml in years 2000 and 2001 and in comparison with 1997 a great progress was achieved, but the year 2001 was worse than 2000.

In years 2000 and 2001 the influence of farm and years on somatic cells count in stable milk samples was highly statistically significant ($P \leq 0.0001$) as we have found out also for years 1995, 1996 and 1997.

Table 2

Estimate of differences of studied systematic influences on (logarithmic) somatic cells count in stable milk samples (Scheffe's test)

Effect	Difference	Estimate±Std. Error	t-value	P
Year	2000-2001	0.05505±0.008519	6.46	0.0001
Season	Summer-Winter	0.00514±0.008519	0.60	0.5466
Farms	A-D	0.09154±0.01205	7.59	0.0001
	A-B	0.05831±0.01201	4.86	0.0001
	A-C	0.09034±0.01201	7.52	0.0001
	D-B	0.03323±0.01206	2.76	0.0574
	D-C	0.00120±0.01205	0.10	0.9997
	B-C	0.03203±0.01201	2.57	0.0709

From *Table 2* is evident that differences in somatic cells count in stable milk samples are statistically highly significant ($P \leq 0.0001$) between years and farms A and D, A and B, A and C.

Table 3

The mean SCCis (10^3/ml) in milk of individual cows and LSCCis in 2000 and 2001 by individual farm

Farm	Year	No. of samples	Mean	Medi-ana	Mad	SD Mad	Min.	Max.
A	2000	2439	533.9	217.0	166.0	246.1	4.0	5000
	LSCCis		5.36	5.34	5.22	5.39	3.6	6.7
	2001	2417	567.2	214.0	166.0	246.1	4.0	5000
	LSCCis		5.37	5.33	5.22	5.39	3.6	6.7
B	2000	1729	388.3	114.0	84.0	124.5	4.0	5000
	LSCCis		5.11	5.06	4.92	5.09	3.6	6.7
	2001	2641	467.9	162.0	126.0	186.8	4.0	5345
	LSCCis		5.22	5.21	5.10	5.27	3.6	6.73
C	2000	4087	371.2	136.0	91.0	134.9	1.0	5000
	LSCCis		5.17	5.13	4.96	5.13	3.0	6.7
	2001	4120	467.9	175.0	119.5	177.2	1.0	5000
	LSCCis		5.28	5.24	5.08	5.25	3.0	6.7
D	2000	2257	360.4	131.0	83.0	123.0	1.0	5000
	LSCCis		5.17	5.12	4.92	5.09	3.0	6.7
	2001	2252	448.1	157.0	103.0	152.7	1.0	5000
	LSCCis		5.25	5.20	5.01	5.18	3.0	6.7
A+B + C+D	2000	10512	409.3	760.2	100.0	148.3	1.0	5000
	LSCCis		5.20	5.16	5.0	5.17	3.0	6.7
	2001	11430	485.0	855.7	125.0	185.3	1.0	5345
	LSCCis		5.28	5.24	5.10	5.27	3.0	6.73
TOTAL	2000 and 2001	21942	448.8	158.0	112.0	166.1	1.0	5345
	LSCCis		5.24	5.20	5.05	5.22	3.0	6.73

Farm influence F-value=20.94 P≤0.0001
Season influence F-value=47.92 P≤0.0001
Year influence F-value=904.19 P≤0.0001

Since the nature of somatic cells distribution in milk samples of individual cows is different than in stable samples, in statictical processing beside mean values and mediana there were also calculated the mediana of deviations from mediana (Mad). Exceptional extreme values (e.g. $5x10^6$) in stable samples are nullified, and in individual samples they change the distribution (there is no normal distribution any longer). Standard deviation is not quoted as with such sample distribution (measurement) it is not logical.

Table 3 shows that the somatic cells count for both years is on average $448.8x10^3$/ml of milk, LSCCis is 5.24/ml, mediana $158.0x10^3$/ml, and Mad $112.0x10^3$/ml. Also the somatic cells count in milk samples of individual cows is greatest on farm A as the mean is $533.9x10^3$/ml of milk, LSCCis is 5.35/ml in 2000 and $567.2x10^3$/ml, LSCCis is 5.37/ml in 2001.

As evident from *Table 3* there is highly statitistically significant (P≤0.0001) impact of all three studied influences on somatic cells count in milk samples of individual cows.

Table 4

The estimate of differences of studied systematic influences on (logarithmic) somatic cells count in milk samples of individual cows

Effect	Difference	Estimate±Std. Error	t-value	P
Year	2000-2001	0.2001±0.006656	30.07	0.0001
Season	Summer-Winter	0.04316±0.006236	6.92	0.0001
Farms	A-D	0.1664±0.03232	5.15	0.0001
	A-B	0.2302±0.03016	7.63	0.0001
	A-C	0.1539±0.02737	5.62	0.0001
	D-B	0.06376±0.03233	1.97	0.0486
	D-C	0.01252±0.02975	0.42	0.6740
	B-C	0.07628±0.02738	2.79	0.0054

From *Table 4* is evident that in somatic cells count in milk samples of individual cows there are highly statistically significant ($P \leq 0.0001$) differences between years, seasons and between farms, except between farm D and C ($P \leq 0.6740$). Difference between farm D and B is significant on the level $P \leq 0.0486$, and the difference between farm B and C on the level $P \leq 0.0054$.

In our research the somatic cells count in milk samples of individual cows ranged from the minimum 1 thousand to the maximum $5345x10^3$/ml of milk. *Sainsbury* (1998) quotes that with cow with $1x10^3$- and more somatic cells/ na ml the production of milk is smaller by 900 kgs. According to *Edmondson* (1998) the cow health condition with regard to mastitis should be good if there are less than $100x10^3$/ml somatic cells in milk of individual cow, at 100 to $200x10^3$/ml the cows are probably not infected, between 200 and $400x10^3$/ml there is the possibility of infection, and over $400x10^3$/ml of milk there is the problem of subclinical infection.

Statistical indicators in *Tables 1* to *4* show that also in our research environmental factors have a great influence on increased somatic cells count as emphasized also by *Reents* (1997). In our opinion these influences on studied farms are still not being eliminated effectively enough. This is also pointed out by the *Table 5*, from which is evident that in the year 2001 during determination of somatic cells in milk samples of individual cows the number of cows with more 200 to $400x10^3$ cells/ml was increased, and there was even more increased (4.65%) the number of those with more than $400x10^3$ cells/ml; these were 23.07% in 2000, and 27.72% in 2001.

Table 5

The number and share of milk samples of individual cows categorised in classes according to Edmondson (1998) for all farms together per year

Somatic cells 10^3/ml	Year 2000		Year 2001	
	No. of samples	%	No. of samples	%
to 100	4073	38.75	3864	33.81
100-200	2314	22.01	2344	20.51
200 - 400	1700	16.17	2053	17.96
over 400	2425	23.07	3169	27.72

Edmondson (1998) states that the determination of somatic cells count in milk of individual cows is a big problem since by this it is determined which quarter and how many quarter were infected, and just as well not the infection type and degree. He also quotes that the somatic cells count of individual cows can be useful for determination of problematic cows, but these findings must be base at least on three consecutive sample takings. If the samples are taken from eachindividual quarter, only then can be determined which and how many quarters are affected, but with this the infection type and degree are not determined (bacteriological analysis).

Table 6

The correlations between somatic cells count and cases of mastitis, between milk quantity and somatic cells count

	SCCis	LSCCis	SCCss	LSCCss	Milk quantity
SCCss	0.608	0.568			
	P≤0.0001	P≤0.0001			
LSCCss	0.613	0.569			
	P≤0.0001	P≤0.0001			
Milk quantity	-0.328	-0.266	-0.278	-0.269	
	P≤0.001	P≤0.01	P≤0.006	P≤0.008	
No. of mastitis	0.275	0.102	0.158	0.162	0.332
	P≤0.008	P=0.335	P= 0.124	P=0.114	P≤0.001

There were determined statistically significant correlations between somatic cells count in milk samples of individual cows and number of cured cases of mastitis (r=0.275, P≤0.008), between milk quantity and number of cases of mastitis (r=0.332, P≤0.001), between somatic cells count in stable milk samples and milk quantity (r=-0.278, P≤0.006) and SCCis and milk quantity (r=-0.328, P≤0.001). Correlation between somatic cells count in stable milk samples and milk samples of individual cows is highly statistically significant (r=0.608, P≤0.0001).

CONCLUSIONS

Our research shows how numerous and complex are environmental factors that are the most frequent cause for manifestation of mastitis and increased somatic cells count in milk. In stable samples as well as in milk samples of individual cows the somatic cells count in milk oscillated considerably. On their count highly statistically significant (P≤0.0001) is the influence of farm (and management) and studied years, and on SCCis also the season influence. These influences comprise numerous factors - from zoohygienic conditions, nutriton to management and supervision of all procedures on farm. In our opinion, on studied farms the first place is occupied by zoohygienic conditions in stable, especially in milking place, and supervision. Only cooperation of all expert (veterinary, tehnologist, equipment experts) and leading workers can give long-term success in reduction of cases of mastitis.

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