Correlations Between Somatic Cells Count and Milk Composition with Regard to the Season

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SUMMARY

On four farms with 1100 cows of Black-and-White breed the correlations between somatic cell count (SCC) in milk and milk composition in different seasons of the year were studied. Three-year data from AP milk recording were analysed (years 2000 to 2002), which meant 29,298 samples of milk. Milk fat, proteins and lactose were determined using Milco-Scan while somatic cells were determined with Fossomatic 90. The three-year average content of fat was 4.16 % (CV=18.75 %), 3.41 % (CV=12.02 %) of proteins, and 4.58 % (CV=5.68 %) of lactose. SCC averaged to 499.2 x 10^3 / ml milk. The three-year average showed a statistically significant ($p \leq 0.0001$) positive correlation between LSCC and fat content (0.130) and protein content (0.240), and a statistically highly significant negative correlation between LSCC and lactose content (-0.423) and daily milk production (-0.286). In special seasons of the year the correlations for fat (0.177), proteins (0.287) and amount of milk (-0.327) were the highest in spring, while (-0.461) in autumn for lactose; all of them were statistically highly significant. The milk composition was in a statistically highly significant correlation with SCC in milk and year season.

KEY WORDS

milk, correlation, milk composition, somatic cells

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INTRODUCTION

Somatic cell count (SCC) in milk is highly correlated to udder conditions but somatic cells are not the only and the most reliable proof for udder inflammation. Any udder troubles are displayed in numerous changes of structure and udder functions that furthermore cause changes in milk composition. Cows with mastitis have almost all milk components changed. Therefore data on milk composition together with other data or without them are often used for general estimation of animal health, udder conditions and as an indicator of subclinical mastitis, feeding errors, causes of metabolic disorders, while the breeder is informed on economy and strategy of management.

Milk composition is affected by other factors like breed, age, number of lactations, the phase of lactation (physiological) and technology of hausing, the season of the year, feeding (environmental factors), hence all effects should be considered when we search the reasons for changes in milk composition.

Among the environmental factors the season of the year and feeding of cows have a considerable influence on basic milk components. The effects of the season of the year have been differently evaluated by various authors for the reason that geographic and climate conditions that cannot be influenced should be considered. The season of the year is often connected to different food regimes. Quality and kind of fodder as well as food intake are connected to the food regime. Food regime offers many possibilities to the breeder because using calculated diets that contain nutritional and mineral matters according to the needs of the animal and the structure of the diets that enables adequate intake, good digestion and metabolism are enabled which on the other had effects on the milk composition. Lyatuu and Eastridge (2003) reported that changes in milk composition are more related to feeding factors than to genetic ones, hence for better correlations among variables (composition) the food intake is more important than the content of nutritive matters in a diet. Nevertheless, the season of the year considerably affects the food intake.

The aim of our work was to study the effect of somatic cells in milk on other components of milk on 4 farms with dairy cows from the defined region. We were interested in those parameters that are used for aims of selection, i.e. the relations between SCC and contents of fat, proteins and lactose in milk. We were also interested in the effects of the season of the year on the above milk components and correlations between somatic cells and milk composition in different seasons of the year.

MATERIAL AND METHODS

Four farms with 1100 cows of Black-and-White breed that were in the AP milk recording in the years 2000 to 2002 were included into our research. The production technology and food regime were equal on all farms. The winter diet consisted of hay, grass and maize silage, supplementary feeding mixtures and feeding mixture for production. In summer animals were on pasture having supplementary diets in stall. Supplementary fodder consisted of hay, maize silage (grass silage when needed) and feeding mixtures. The average milk production per cow differed among farms during the years 2000 and 2002, i.e. from the lowest 24.3 kg/cow to the highest 26.6 kg/cow a day.

Milk production per cow, the contents of fat, proteins, lactose and SCC were analysed every month. Fat, proteins and lactose were determined using Milco-Scan, while the somatic cell count was determined with Fossomatic 90 (Foss electric). All analyses were done in the laboratory of Dairy Institute of Biotechnical Faculty in Ljubljana. 29,298 samples of milk were analysed.

Data were statistically processed with SAS/STAT (1994). Since somatic cells were not normally distributed cell count data were transformed to their logarithmic to obtain their normal distribution.

Correlations between SCC and contents of fat, proteins and lactose were estimated on whole material and for single effects. Differences between mean values for single effects were estimated with Bonferron's t-test.

RESULTS

Table 1 shows average milk composition for three years and some statistical indices.
Looper et al. (2001) reported on 3.64 % of fat on average in milk of Holstein-Friesian breed. In Slovenia the average fat content was 4.12 % for 18,484 records for Black-and-White cows with 7,699 kg milk per cow that were in AP milk recording in 2001, and in the year 2000 for 17,164 records with the average milk production 7,439 kg and fat content 4.09 % (Sadar and Podgoršek, 2002).

Even though the differences between the content of fat on the studied farms were between 1.5 and 9.0 %, the average contents for some other years were close: 4.17 % in year 2000, 4.17 % in 2001 and 4.15 % in 2002. The three-year average content of fat in milk (4.16 %) was a bit higher than the AP results showed for Black-and-White breed in Slovenia. Cows that were selected to higher milk production had often problematic fat content in milk. This is especially the fact in herds with unbalance food regime.

Table 1. Basic statistics for daily amount of milk, contents of fat, proteins and lactose (%) in milk and SCC (10^3 /ml) in milk in the years from 2000 to 2002..

Milk parameters	No. of samples	Mean	Standard deviation	Coefficient of variability	The lowest	The highest
Milk, kg	29,298	25.15	8.22	32.68	0.30	57.0
Fat	29,264	4.16	0.78	18.75	1.50	9.0
Proteins	29,288	3.41	0.41	12.02	2.09	7.0
Lactose	29,279	4.58	0.26	5.68	1.81	9.12
SCC	28,290	499.2	866.3	173.55	1.0	5,345.0
LSCC		5.29	0.59	11.09	3.0	6.7

Table 2. Correlations between LSCC and milk components

	Milk	Fat	Proteins	Lactose
Fat	–0.414			
Proteins	–0.571	0.534		
Lactose	0.197	–0.036	–0.114	
LSCC	–0.286	0.130	0.240	–0.423

Variability for content of proteins in milk is lower than for the content of fat (Table 1). Looper et al. (2001) reported on 3.16 % of proteins in milk in HF breed. According to the AP milk recording the content of proteins in milk in Slovenia was 3.33 % in Black-and-White cows' milk in the years 2000 and 2002 (Sadar and Podgoršek, 2002). Steinwidder and Wurm (1998) reported on the content of proteins in milk between 3.2 and 3.8 %. Cows that produced milk with less than 2.8 % and more than 3.5 % of proteins in milk in the time of insemination the insemination rate was lower (Cannon, 2003). Even the content of proteins was the lowest on the studied farms in the year 2002 being 3.39 % and in the year 2001 3.42 % compared to the year 2000 with 3.41 %. The proteins in milk of the studied cows were above the average of the cows in AP milk recording. The contents of fat and proteins in milk shown in Table 1 stand for adequate feeding and high genetic abilities of animals on the studied farms.

In Slovenia, milk produced by Black-and-White cows contained 4.53 % of lactose (Babnik and Podgoršek, 2002), while Stalling (1998) reported on 4.9 % of lactose in milk produced by Holstein breed cows. On the studied farms the highest amounts of lactose were found in the year 2000 – 4.59 %, in the year 2001 there was 4.56 % of lactose and in the year 2002 4.58 %. Klopčič and Moening (1996) reported on 4.57 % of lactose in Black-and-White cows' milk in AP milk recording in Slovenia in the period from October 1995 to October 1996 (n=83,420). The three-year average content of lactose in milk was above the reports of the mentioned authors. The content of lactose is affected by several factors (breed, age, number of lactations, the phase of lactation), but the health of udder is the most important one. The content of lactose is correlated with the proteins (and fat) since the biosynthesis of both is processed in the same cells in the mammary gland. The content of lactose in milk shows lower variability.

SCC in milk is important due to discovery and treatment of mastitis. According to the three-year data SCC increased on the studied farms. In the 2000 there were 421.3 x 10^3 /ml somatic cells, in the year 2001 513.2 x 10^3 /ml, and in 2002 573.6 x 10^3 /ml milk. Contrary to the reports of some authors (Agabriel et al., 1995) SCC was higher in winter. Referring to the production technology zoo-hygienic conditions are more favourable on pasture during summers with less precipitation than in stalls in winter.

The basic components of milk are in close correlation with SCC. At 5 % risk statistically highly significant positive correlations ($p \leq 0.0001$) were found out between LSCC and contents of fat and proteins, and statistically highly significant negative correlations between LSCC and content of lactose and amounts of milk. A statistically highly significant correlation was found between the contents of fat and proteins and contents of proteins and lactose in milk.

As 5% risk mean values among all classes of SCC differed statistically significantly

except for classes 3 and 4 and 4 and 5. Regarding the content of fat a statistically significant difference was found for mean value for fat in the first class of SCC from the mean value of all other four classes. Regarding the content of proteins no statistically significant differences were shown for mean values for the fourth and fifth, fourth and third, and fifth and third class of SCC. Concerning the content of lactose differences among mean values for all classes were statistically significantly different.

Table 3 shows that somatic cells affect daily milk production per cow as well as milk composition. Daily milk production per cow lowered from the first to the fifth class SCC for 5.40 kg (19.39 %). Parallel to increased SCC the content of fat increased up to the third class (for 0.25 %), and up to the fourth class the content of proteins (for 0.23 %). Most evident are changes in lactose content: more SCC in milk means lower content of lactose, almost 0.30 % in total.

The correlation between SCC, contents of fat (0.167) proteins (0.225) and lactose (-0.093) was statistically

Table 3. Changed amounts of milk and contents of fat, proteins and lactose with regard to SCC in milk

SCC (10^3/ml)		<100	<250	250–500	500–1,000	>1,000	F (p≤0.0001)
No. of samples		10,333	7,644	4,344	3,326	3,650	
Milk	Mean	27.85	24.78	23.40	22.90	22.45	527.74
	Standard deviation	7.86	7.42	8.01	8.62	8.48	
Fat	Mean	4.01	4.23	4.26	4.25	4.25	148.26
	Standard deviation	0.73	0.75	0.79	0.79	0.89	
Proteins	Mean	3.28	3.45	3.50	3.51	3.50	465.16
	Standard deviation	0.35	0.38	0.41	0.45	0.47	
Lactose	Mean	4.68	4.61	4.54	4.49	4.38	1,329.47
	Standard deviation	0.20	0.21	0.23	0.27	0.33	

Table 4. The effect of season on milk production, contents of fat, proteins and lactose (%) and SCC in milk (10^3 /ml)

Traits		Mount of milk		Fat %		Proteins %		Lactose %		LSCC	
Season	No. of samples	Mean ± standard deviation		Mean ± standard deviation		Mean ± standard deviation		Mean ± standard deviation		Mean ± standard deviation	
XII – II	7,318	23.9	8.17	4.44	0.78	3.49	0.41	4.58	0.25	5.32	0.59
III – V	7,190	25.9	8.84	4.16	0.79	3.40	0.41	4.62	0.26	5.25	0.60
VI – VIII	7,240	26.5	7.99	3.87	0.71	3.27	0.37	4.57	0.25	5.27	0.60
IX – XI	7,350	24.3	7.56	4.18	0.73	3.46	0.40	4.56	0.26	5.32	0.55
F, P≤0.0001		177.34		692.82		445.93		90.55		30.84	

significantly high up to the first class SCC (p≤0.0001), in the second class the correlation with the fat (0.035) was statistically significant on the level p≤0.002, while with proteins (0.079) and lactose (-0.111) and amount of milk (-0.076) on the level p≤0.0001. In the third class only the correlation with lactose (-0.089) was highly statistically significant and in the class 4 also the correlation with lactose (-0.034) on the level p≤ 0.047 and amount of milk (-0.037) on the level p≤0.03; in the fifth class with lactose (-0.289) and amount of milk (-0.093) on the level p≤0.0001, and with fat (0.063) on the level p ≤0.0002 and proteins (0.060) on the level p≤0.0003. Considering the findings that the lowest content of lactose that shows the danger of mastitis is around 4.5 % (Babnik and Podgoršek, 2002) than in the above case this danger exists at SCC higher to 500 x 10^3 per ml of milk.

Environmental factors that affect the food intake could be highly correlated to the amount and composition of milk. Table 4 shows that differences in the contents of fat, proteins, lactose and SCC in milk vary between seasons of the year. Differences between mean values for seasons and different components and amount of milk are statistically significant except the difference between spring and summer for the content of fat, differences between winter and autumn and differences between summer and spring for LSCC. The content of fat and proteins was the highest in winter and the lowest in summer, while the lactose content was the highest in spring and the lowest in autumn, however SCC in milk was the highest in winter and the lowest in spring.

Gencurova and Hanuš (1997) reported on the highest content of fat in milk in winter that diminished in spring and achieved the minimum in August. The content of proteins was the highest at the end of summer and in autumn while the content of lactose was low in November and remained so all winter months. SCC was the highest in winter. Kuczaj (2001) reported on extremely high content of fat in milk bulk in November (3.98 %) and in February (4.56 %), content of proteins in October (3.17 %) and March (3.60 %), SCC in October (113.7 x 10^3 /ml milk) and June (316.7 x 10^3 /ml milk) in Black-and-White cows with 9,500 kg milk a year. Stalling (2003) reported on regular fall of fat in Holstein breed from 3.7 % in March to 3.4 % in August and proteins from 3.2 % to 3.1 %. The fall of proteins in milk in summer was affected by high temperatures; at over 30 degrees C milk production and content of protein fell due to lower food intake. Cows that calved in winter and spring had higher content of proteins in milk in comparison to those that calved in summer and autumn (Cannon, 2003). The highest content of fat and proteins in winter was influenced by different food regime in summer and winter besides climate conditions, since from all the studied parameters the mentioned components of milk depended most on feeding.

Klopčič and Moening (1996) reported that milk produced by cows in AP milk recording in 1995/1996 contained on average 4.52 % lactose in September and 4.64 % in January. Contrary to our findings most authors reported on higher SCC in milk in summer (Hanuš and Suchanek, 1991; Agabriel et al., 1995).

Correlations between LSCC and contents of fat (0.177), proteins (0.287) and amount of milk (-0.327) were the highest in spring, and lactose (-0.461) in autumn. All correlations were statistically highly significant.

DISCUSSION

Reports of other authors on relation between SCC and contents of fat, proteins and lactose in milk differ the most in SCC and fat content. Gajdušek (1996) did not find a significant influence of SCC on the content of fat in mastitis affected cows, only the composition of fat and the size of fat balls was changed. Even Kuczaj (2001) did not find any statistically significant correlation (0.130) between SCC in milk bulk sample and the content of fat. Klinkon et al. (2000) monitored the milk composition on sample of 105 cows (n=804) for a year but they did not find higher content of fat at higher SCC. These findings are in agreement to the reports of Kitchen (1981) stipulating that in case of mammary gland infection the content of fat in milk only slightly lowered, according to Harmon (1994) from 3.5 to 3.2 %. According to Kitchen a higher decrease was found in SCC higher to 2,500 x 10^3 /ml. In such a case cows are infected by clinical mastitis.

Paura et al. (2002) reported on positive correlation between LSCC and content of fat in milk (0.064**). Sawa and Piwczynski (2002) reported on similar findings when they determined a statistically highly significant correlation between SCC and fat content in milk from 29,000 cows. Our findings (0.130**) lying between LSCC and the content of fat in milk are similar to the above mentioned findings.

The content of proteins in milk remains stable at increased SCC or it is slightly increased, while the composition of proteins and the ratio of fractions are changed (Gajdušek, 1994). Kuczaj (2001) found a positive correlation (0.289) between SCC and content of proteins in milk. Paura et al. (2002) reported on a correlation between LSCC and content of milk -0.275** , while Sawa and Piwczynski (2002) informed on statistically highly significant correlation. Klinkon et al. (2000) notified that the content of proteins in milk increased linearly to higher SCC, the difference between the lowest value 3.31 ± 0.33 % and the highest 3.51 ± 0.39 % was statistically highly significant. Our results agree with the above reports - higher SCC matches with higher content of proteins in milk up to SCC 1,000.0 x 10^3 /ml.

Lactose is one of the most sensitive parameters in milk that displays disorders in secretory tissues (Gajdušek, 1996). Due to infection of mammary gland the biosynthesis of lactose is diminished. Kitchen (1981) stipulated that regular measurement of lactose is a more reliable indicator of disorders in mammary gland than SCC is. Berning et Shook (1994) found out that the content of lactose in the mentioned sample was not a reliable indicator of mastitis when the correlation of SCC to the content of lactose in milk was on the level -0.49. Higher SCC in milk caused a decrease in the content of lactose in milk. Hanuš and Gabriel (1991) found a statistically significant ($p \leq 0.01$) lowered content of lactose at SCC from 300 x 10^3 /ml milk to SCC of 1,000.0 x 10^3 /ml (n=3,978); a correlation between SCC and lactose was -0.25 (Hanuš and Suchanek, 1991). Hanuš et al. (1994) even reported that lactose in milk could indicate the health conditions of udder. Klinkon et al. (2000) stipulated that the content of lactose in milk together with SCC showed pathological events in udder, which could be of great help at udder control. Sawa and Piwczynski (2001) reported on statistically highly significant negative correlation between SCC and content of lactose, while Paura et al. (2002) informed on correlation between LSCC and lactose -0.398 **. Ingalls (2003) found out lower content of lactose in milk, 0.69 % when somatic cells increased (from 4.90 % at SCC < from 100 x 10^3 /ml to 4.21 % at > as 1,000.0 x 10^3 cells per ml of milk). In the studied cows the correlation -0.388 *** confirms the statements of other authors. Low content of lactose shows metabolic and functional disorders in udder tissues, which is not the result of udder inflammation but of metabolism disorders (Zadnik in Jazbec, 1993).

The year season, which belongs to environmental factors, affects differently the content of the milk and SCC. Hamann et al. (1997) reported on higher content of proteins and fat in autumn and winter following by spring and summer. Klinkon et al. (2000) informed on lower content of fat in June samples of milk while the highest content of fat was found in November, but the highest contents of proteins were found in October and November, the content of lactose was the lowest in December. SCC was higher in summer months. Kuczaj (2001) notified about a negative correlation between the content of fat (-0.533**) in milk bulk, content of proteins (-0.386*) and SCC (- 0.141) in the summer season, while on the other hand Looper et al. (2001) reported on higher content of fat and proteins in autumn and winter following by spring and summer. Our results agree with the findings of latter authors.This variation is related to changes in both the types of feed available and climatic conditions.

Besides genetic and environmental factors several other factors affect the milk composition. The health conditions especially udder conditions are of great importance. Continuous changes in milk composition we meet every day lead to the study and consideration of all factors that affect the milk composition.

CONCLUSION

A three-year average contents of fat, proteins and lactose in milk from studied cows are higher than the average for all cows in the AP milk recording in Slovenia in 2000 and in 2001. SCC in milk increases. The infection of mammary gland affects the milk composition. SCC is in a highly statistically significant correlation with fat and proteins and in a negative correlation with lactose and amount of milk.

The year season has a statistically highly significant influence on the milk composition and somatic cell count. The year season positively affects the contents of fat and proteins and negatively the amount of milk and is the highest in spring while the highest negative effect on the content of lactose was found in autumn.

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