Acta Agraria Kaposváriensis (2002) Vol 6 No 2, 177-185
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Potential use of milk analyses for udder health control in highly productive dairy herd

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ABSTRACT

The differences of milk composition in highly productive dairy herd in milk bulk tank and from individual dairy cows in the frame of referral A4 (AP) and B control were analysed in the paper. During the experiment the oscillations of somatic cells count (SCC), of the content of lactose and enzyme LDH activity were monitored. Significant oscillations of the SCC and enzyme LDH activity in milk tank were noticed. The somatic cell count in milk tank varied between 87 and 770 thousand cells/ml milk, and enzyme LDH activity between 7 and 173 U/l milk. When the SCC in the milk tank exceeded 400 thousand SCC, enzyme LDH activity exceeded 100 U/l milk. Both parameters were used for udder health control. The content of lactose, which also shows udder diseases, lowered only when the SCC in the milk tank exceeded 600 thousand SCC/ml milk. AP and B control were carried out on the farm at the time of no udder disorders reported in the herd.
(Keywords: dairy cows, milk, lactose, somatic cell count, enzyme LDH activity)

INTRODUCTION

Economic milk production requires high milk production per cow, milk with a high nutritive value and excellent hygienic quality as well as healthy cows. Milk composition could show faults in nutrition and management of herd as for example disorders in health and hygienic quality of milk. Hence it is important to perceive the above connections in production of quality milk and healthy cows.

Health and nutritional disorders that result in lower production and clinical diseases can hardly be noticed at the beginning, therefore suitable preventive advisory programmes are necessary. In the first place results of milk tank analyses and from individual dairy cows that are easy to be taken and have several parameters measured will become the basic diagnostic material for detection of udder, metabolic, reproductive diseases, and parasites.

Production and health control in dairy cows have heretofore been proceeded by so called milk profile test. Milk is analysed regularly according to milk recording system. Samples are easy to be taken, and individual animals or the whole herd are recorded. The results of milk analyses are important for the farmer, nutritional experts and veterinarians. Milk samples show health conditions of an animal more quickly, easily and cheaply than blood assays, which is very important from the point of view of production.

Milk analyses indicate several parameters of quality like contents of fat, proteins, lactose, dry matter, somatic cell count, contents of urea, potassium, sodium, chlorine, acetone, the enzyme LDH activity and so on. According to the experiences the results of

milk analyses are not adequately used in herd control. We would like to show the dynamics of various milk components on the base of individual and milk tank samples in highly productive dairy herd.

In highly productive dairy cows mastitis and high SCC are very frequent. Farmers whose main income derives from quality milk sale would like to control udder health in dairy cows on the permanent basis. Some milk components like the content of lactose, SCC and the enzyme LDH activity are the most suitable indicators of udder conditions. In practice milk components cannot be measured every day because it would be too expensive. Daily control of milk quality can be achieved by frequent analysis of milk tank samples. We wondered if the results of milk tank gave adequate information on udder health conditions in the herd. Therefore in the farm with the average annual milk production above 10,000 kg milk per cow milk tank sample composition was compared to the results of analysis of milk from individual diary cows at monthly milk recording.

In Slovenia the quality of milk is determined by regulations. Besides the content of fat and proteins in milk the total number of microorganisms (TNM) and somatic cell count (SSC) are of great importance. The above traits significantly affect the selling price on the farm. Farmers look forward to high content of fat and proteins in milk and to a low presence of TNM and SSC in order to achieve the highest price per litre of sold milk. Milk composition is important also because it shows important facts about the supply of energy and proteins (proteins, urea) in animals as well as health conditions, especially of udder and are an important indicator of some diseases.

A high content of milk fat in milk can show ketosis, acidosis and cystic degeneration of ovary. At the beginning of ketosis and energy deficiency in a daily ration the milk contains more milk fat. When ketosis is clinically noticed (no appetite) the content of milk fat is low (*Klinkon et al*., 1999a).

Proteins are the most valuable components of milk. The content of proteins is most often affected by ketosis and hypocalcemia. Visible and invisible udder diseases (mastitis) cause lower content and poor composition of proteins in milk due to increased fermentation of already built milk proteins especially casein in mammary gland (*Klinkon et al.,* 2000).

Lactose in milk is a disaccharide composed of glucose and galactose. Cow milk contains on the average about 4.60% of lactose (*Walstra,* 1984). The content of lactose in milk depends on the breed, stage of lactation, successive lactation, health conditions and other factors (*Miljkovič,* 1984). Lactose in milk is more stable than other components (*Larson* and *Smith,* 1974). Several researches proved the relation between the higher SCC in milk and lower contents of lactose. Milk that contains more than million of SCC/ml usually does not reach 4.40% of lactose. Low concentration of lactose proves a metabolic functional disorder of udder tissue that is not a consequence of udder inflammation but the result of metabolic disorders. Considering the fact that lactose derives from glucose in blood it is obvious that only a suitable nutrition will result in adequate level of glucose in blood (*Klinkon et al.,* 1999b).

Somatic cells in milk are represented by epithelial cells, i.e. cells of gland tissue, leukocytes – white blood cells and lymphocytes – a group of white blood cells. Somatic cell count affects the selling price on the farm, therefore it is very important to have healthy cows in the herd. Somatic cell count is very substantial for each farmer because it reveals cows with visible or invisible mastitis. Milk from healthy udder in the normal lactation contains about 100,000 cells in ml milk. *Klopčič* (1994) reported that SCC was increased during 8 to 14 days after calving, decreased till the 60^{th} day after calving when it reached the lowest values, and is followed by an increase until drying. Somatic cell

count is considerably increased in the case of udder inflammation. When the SCC increases above 400,000 cell/ml the danger of acute mastitis is present since the risk factor has been increased by three times. A team work of a farmer, control and selection and veterinary services can result in successful and effective struggle for satisfying udder health and thus a good quality of produced milk, which is very important for the farmer (payments are based on quality of milk) and milk industry that needs good quality milk for production of quality products.

Somatic cell count in milk has been lowered to achieve better quality of milk. Higher somatic cell count (neutrophyl granulocytes, other leukocytes, epithelia cells) in milk is the result of damages in alveolar walls of the udder. Damages could be the outcome of infections, chemical effects (usage of antibiotics), physical effects (traumatic damages, bad function of milking machine) and stress conditions. Somatic cell count in milk depends on the age of dairy cows (milk from older animals contains more somatic cells than milk from younger ones), on the season (in spring SCC is lower than in autumn). Somatic cell count changes during the day as well, morning milk contains less SCC than evening milk; *Mijovič et al.,* 1995).

Klinkon et al. (1999b) found out that higher somatic cell count caused lower percentage of lactose. The content of milk fat is not affected by somatic cell count while milk proteins increase linearly to somatic cell count. Higher SCC affects some biochemical parameters in milk. More somatic cells cause higher enzyme LDH activity, higher concentration of sodium and chlorine while the concentration of potassium decreases.

Only healthy and regularly supplied cows can give milk with normal composition and in regular amounts. Both composition and amount of milk are most affected by mastitis – inflammation of udder. The inflammation of udder causes the following changes in milk composition:

- The ratio of nitrogen fractions is destroyed.
- The amounts of casein and lactose are lowered.
- The amount of calcium is lowered.
- The amount of whey proteins increases (albumins, imunoglobulins).
- The amounts of sodium and chlorine are increased.
- The number of leukocytes and amounts enzyme of catalysis are increased (*Zorko*, 1992).

Zadnik et al. (1993, 2001) studied the content of sodium, potassium, chlorine and somatic cell count, and enzyme LDH activity in milk They found out that the above parameters show health conditions of udder. They found increased amounts of sodium (above 24 mmol/l), chlorine (above 35 mmol/l) and enzyme LDH activity (above 100 U/l) while the content of potassium decreased (below 38 mmol/l) in samples of milk tank with more than 400,000 SC/ml.

Besides mastitis several other diseases and disorders that affect the composition and amounts of milk are known. Most known are metabolic disorders that appear at digestion of carbon hydrates (ketosis, acidosis) and of some mineral matters (parturient paresis).

MATERIALS AND METHODS

Presentation of the family farm

The farm owns 9 ha and hires 6 ha of agricultural lands. Dairy cows (n=20 to 22) were free in stables all the year. Their ambition is to produce high quality fodder (hay, grass

and maize silage). Components for feeding mixtures are bought and mixed by themselves. Feeding mixture is fed automatically by computer assistance while grass and maize silage are fed ad libitum. Cows are milked in the milking parlour at passage tandem 2×2 and is computer assisted. They maintain order and cleanness, hence no problems of milk quality are known.

Table 1 indicates the results of control for the period from 1990 to 2001. The highest milk production per cow was achieved in the year 2000 when the average annual milk production per cow exceeded 10,000 kg of milk. Hence the milk production per feeding day and milking day was the highest in the year 2000. The results of milk recording showed that cows produced the richest milk in 1999 and 2001 regarding the contents of fat and proteins. In the last 12 years milk production augmented remarkable; the average milk production per cow was 6.507 kg in 1990 and in 2000 10.226 kg milk per cow per year. It means that the average annual production of milk in the period between 1990 and 2000 increased for 3.719 kg or by 338 kg milk per year. The content of fat was quite high (above 4.0%), while the content of proteins increased especially after 1995 (above 3.33%).

Table 1

Annual milk production of recorded cows in the AP control on the above mentioned farm in the period 1990–2001

Year	No. of cows	Milk yield, kg		Fat	Proteins	Milk yield, kg		Milking days	PTC
		Total	Per cow	%	%	Per FD	Per MD		Days
1990	19.6	127,737	6,507	4.26	-	17.8	19.9	327	388
1991	21.1	143,085	6,784	4.17	-	18.6	20.2	336	366
1992	21.2	162,024	7,646	4.28	-	20.9	22.7	337	404
1993	23.2	209,988	9,069	3.93	3.20	24.9	27.1	335	385
1994	24.1	205,256	8,515	4.01	3.22	23.3	25.1	339	407
1995	25.5	228,050	8,941	4.03	3.15	24.5	27.0	331	389
1996	27.2	243,871	8,964	4.10	3.33	24.5	27.4	328	410
1997	25.3	231,521	9,146	4.29	3.43	25.1	27.4	334	379
1998	25.0	252,244	10,072	4.40	3.35	27.6	29.8	338	391
1999	23.5	227,519	9,696	4.45	3.47	26.6	28.7	338	379
2000	23.8	242,946	10,226	4.47	3.37	27.9	30.1	340	381
2001	23.5	228,326	9,712	4.45	3.47	26.6	28.7	338	379

FD: feeding day; MD: milking day; PTC: period between two calvings

Milk composition in the dairy herd

Between November 2 and December 13 1999 i.e. for six weeks, differences of the amounts and composition of individual dairy cows and milk tank were monitored. After morning milking a daily sample of milk from tank was taken. During the experiment 42 samples of milk were taken.

During the experiment the milk controller recorded production (AP control) twice according to the reference method A4. The milk controller took milk samples from all cows that were milked on the certain day. Basic (contents of fat, proteins, lactose and dry matter and somatic cell count) and biochemical (content of sodium, potassium, chlorine, urea, enzyme LDH activity) parameters of milk were determined in samples of milk from individual cows. The farmer himself recorded milk production three times during

the experiment (B control). He took samples of milk from individual cows once a week from both daily milking. We determined basic and biochemical parameters of milk in those samples too.

Milk samples were analysed in two laboratories. In the Laboratory of Institute for Dairy of Biotechnical Faculty, Zootechnical Department the infrared spectrometry with Milko-Scan 133 was used to determine basic composition of milk and Fossomatic 5000 to determine SCC in milk. In the laboratory of Clinics for Ruminants at the Veterinary Faculty the bio-analyser Cobas Mira was used to determine biochemical parameters in milk (urea, Na, K, Cl, LDH).

Data processing

Collected data were processed by SAS (Version 8) at the Centre for expert work in animal breeding at Biotechnical Faculty, Zootechnical Department.

Basic statistical parameters: mean value ($\bar{x}$), standard deviation (SD), coefficient of variability (CV), minimum and maximum for some studied traits of milk tank within the regular milk recording (AP control), and the farmer's milk recording (B control) were estimated.

RESULTS AND DISCUSSION

Table 2 shows basic statistical parameters for the amount and composition of milk tank and for individual cows obtained at the regular milk recording (AP control) and at farmer's recording (B control).

Table 2

Basic statistical parameters ($\bar{x}$, SD, CV) for milk tank (total daily milk production) and results from AP and B control

Trait	Milk Tank			AP milk recording			B milk recording		
	$\bar{x}$	SD	KV	$\bar{x}$	SD	KV	$\bar{x}$	SD	KV
No. of measure.	42	42	42	43	43	43	64	64	64
Milk, kg	-	-	-	25.40	6.99	27.6	24.3	7.25	29.9
Fat, %	4.47	0.16	3.61	4.75	0.69	14.4	4.64	0.87	18.7
Protein, %	3.57	0.04	1.29	3.67	0.47	12.8	3.62	0.46	12.8
Lactose, %	4.58	0.06	1.37	4.61	0.23	5.04	4.58	0.22	4.70
SSBM, %	8.87	0.05	0.60	9.03	0.56	6.20	8.93	0.50	5.62
SSC x 1000/ml	331	178	53.7	160	239	149	236	517	219
LDH, U/l	102	26	26	63	40	64	72	59	82
Urea, mmol/l	5.67	0.73	12.9	5.80	1.20	20.8	5.49	1.23	22.3
Na, mmol/l	20.93	1.85	8.85	19.51	3.98	20.4	21.42	3.21	15.0
K, mmol/l	40.14	1.49	3.71	39.38	3.02	7.68	40.61	3.01	7.40
Cl, mmol/l	36.57	1.62	4.44	38.93	4.55	11.7	37.27	4.29	11.5

The comparison of milk tank analysis and of individual cows within AP control and B control shows that all components and biochemical parameters differ in mean value. Those differences are higher when milk tank analyses are compared to milk analyses of individual cows within AP control. Lower differences are noticed when the results of

milk tank are compared to the results from B control. The lowest differences of the mean value are noticed when the results of AP and B control are compared. Also the standard deviation and the coefficient of variability are higher in the composition of milk from individual cows (AP and B control) in comparison to the milk tank results. The basic components of milk tank were lower than in milk from individually recorded cows. On the contrary, somatic cell count and enzyme LDH activity were higher in milk tank, but two parameters indicated lower standard deviation and lower coefficient of variability in AP than in B control.

Considering the fact that no important changes occurred in feeding regime during the experiment standard deviations for milk traits were not high. The highest standard deviation was determined for somatic cell count and the enzyme LDH activity and for sodium, potassium and chlorine. The highest variability was noticed in somatic cell count in milk tank whereas it ranged between 87 and 770 thousand per ml of milk during the observation (six weeks). Within the milk recording (AP) the somatic cell count ranged between 12,000 and 1,498,000 cell/ml milk in individual cow. A high variability was observed in enzyme LDH activity (CV=25.6% in milk tank and 82% in milk from individual cows in B control). For the content of urea in milk was CV 12.9% in milk tank and 22.3% in milk from individual cows in B control. In sodium CV ranged between 8.85% in milk tank and 20.4% in milk from individual cows in AP control. Other components indicated lower coefficients of variability.

Figure 1 shows that the content of lactose in milk tank differences during the experiment. Milk contained a lot of lactose at the beginning of the experiment and much less towards the end of it. The AP control was done on the first and the thirtieth day of the experiment. The average content of lactose in the AP control was 4.63%, and 4.60% in the second one. Milk tank contained 4.62% of lactose in the first AP control, and 4.65% in the second one. The farmer did the B control on the tenth, twenty-first and on the fortieth day of the experiment. The first and third control showed that the average content of lactose in milk from individual cows was 4.58% and 4.59% in the second control. Milk tank contained almost equal amounts of lactose as in B control.

Figure 1

Oscillations of the content of lactose in milk from tank

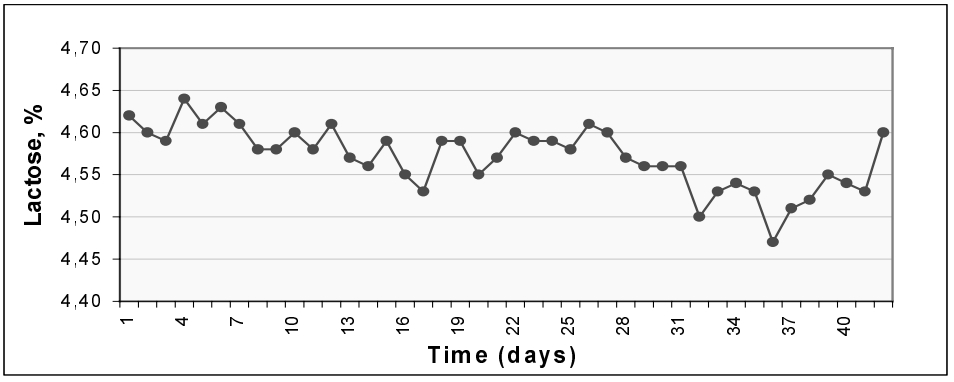

Figure 2

Oscillations of the somatic cell count and enzyme LDH activity in milk from tank

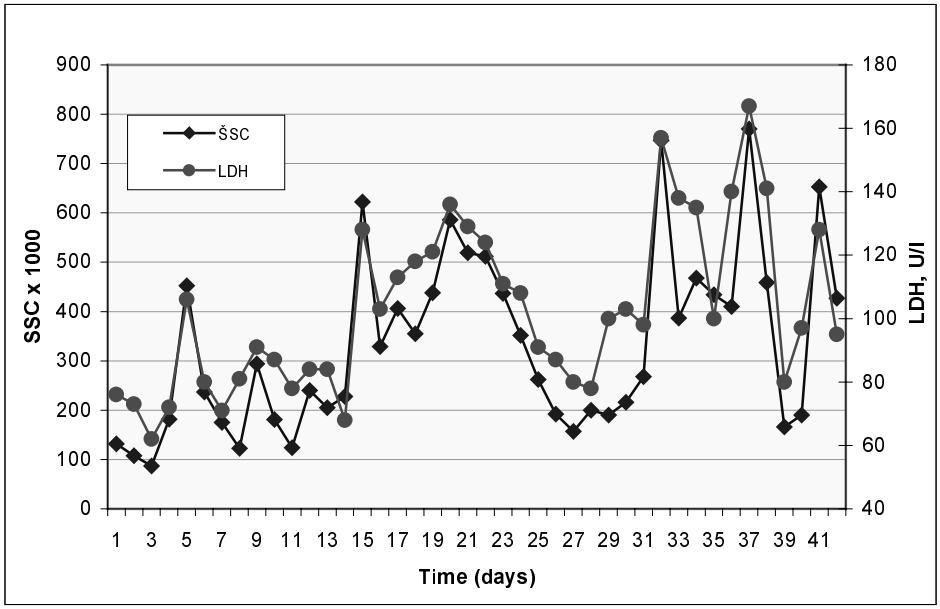

Figure 2 shows that somatic cell count and enzyme LDH activity in milk from tank during the six-week-long experiment varied. During the experiment high oscillations of somatic cell count in milk tank were noticed. Milk tank contained above 400,000 somatic cells/ml milk sixteen times. The AP control was done on those days when milk contained little somatic cells. The average somatic cell count in milk from individual cows was 100,000 in the first AP control (milk tank contained 123,000 somatic cells on that day) and in the second control 223,000 (milk tank contained 216,000 cells). Also B control showed that milk tank did not exceed the allowed limit of 400,000 cell/ml milk. Only in the second control, which was done by the farmer on the 21st day of the experiment, milk tank contained above 500,000 cells while the average SCC in milk from individual cows (B control) was 257,000 somatic cells/ml.

Figure 2 represents also the oscillations of enzyme LDH activity in milk tank. Enzyme LDH belongs to cytoplasmic enzymes and is present in the epithelial cells in milk canals in the udder. During the inflammation process in udder milk producing tissue is affected, therefore enzyme LDH activity increases. Enzyme LDH activity in milk is an important indicator of health condition of mammary gland, especially it shows tissue infections with bacteria and is positively correlated to the somatic cell count and to the content of sodium and chlorine in milk. In our experiment, we have noticed high correlation subsist between the somatic cell count and enzyme LDH activity (r=0.85). During the experiment the enzyme LDH activity exceeded 100 U/l milk eighteen times. Higher values of enzyme LDH were noticed together with higher somatic cell count in milk tank, which is clearly shown in *Figure 2.* When the somatic cell count in milk tank exceeded 400,000 somatic cells/ml milk, the enzyme LDH activity exceeded 100 U/l milk too.

The content of lactose did not change during the experiment as quickly as the enzyme LDH activity did in relation to higher somatic cell count. The analysis of lactose content in milk tank, which is presented in *Figure 1*. and somatic cell count, which is presented in *Figure 2*. showed that the content of lactose lowered when the somatic cell count exceeded 600,000 cell/ml in milk tank.

AP and B control were carried out when no significant udder health troubles were noticed, which is proved by low somatic cell count and low enzyme LDH activity on the milk recording day in milk tank as well as in milk from individual cows. The analysis of lactose content, somatic cell count and enzyme LDH activity in milk tank during the six-week-long experiment showed that the somatic cell count oscillated the most, which is known as an indicator of udder health. Analyses of AP and B control results showed that both controls were carried out in a certain time period (monthly, weekly…) and that they informed farmers on the composition and quality of milk from individual cows only on the day of the milk recording. Milk production is an alive and continuos process that changes, which is shown by oscillations of milk composition.

The farmers will be the happiest if they know the composition of milk tank every day, which could only be enabled by daily analyses of milk tank. If milk tank contains more somatic cells or enzyme LDH activity is increased, a farmer will decide to have milk from individual cows analysed. Due to a narrow correlation between somatic cell count and enzyme LDH activity (*Figure 2*) farmers will be satisfied with the somatic cell count. A more in detail analysis of composition and quality of milk from individual cows will show which cow has an exceeded somatic cell count and is in danger of mastitis. Milk with higher somatic cell count is neither suitable for sale nor for further processing.

CONCLUSIONS

A high production of milk per cow requires the best management system (balanced daily ration, favourable climate and temperature, rearing system and maintenance should enable a high production). Results of milk analyses on the farm that keeps a white-and-black dairy herd show that:

- A six-week-long experiment in which daily oscillations of milk tank composition was studied has shown that somatic cell count in milk tank oscillated the most ranging between 87 and 770 thousand SCC/ml milk.
- The same oscillation curve was noticed in enzyme LDH activity in milk tank. It ranged between 7 and 173 U/l milk.
- When the somatic cell count in milk exceeded 400.000 SCC/ml milk, the enzyme LDH value exceeded 100 U/l milk. Both values represent the critical value that informs the farmer about the mammary gland trouble and of the cases of mastitis in the herd.
- During the experiment the somatic cell count in milk tank exceeded 400.000 cell/ml milk sixteen times, and the enzyme LDH activity exceeded 100 U/l milk eighteen times.
- The content of lactose lowered whenever the somatic cell count exceeded 600.000 cell/ml milk in tank.
- AP and B control were carried out on the days when no serious udder health problems were noticed, which can be proved by the results of milk tank analyses from AP and B control.
- The experiment showed that a once-a-month recording in highly productive dairy herd is not sufficient. A permanent production requires daily observation of milk

composition and quality so that the farmer can take adequate measures in time to prevent serious disorders (better herd monitoring, analysis of changes in the herd, milk analysis per individual cow …).

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