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## **EFFECT OF THE UDDER HEALTH ON THE COMPOSITION AND QUALITY OF QUARTER MILK FROM BLACK-AND-WHITE COWS**

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### **ABSTRACT**

In the experiment involved 186 milk samples obtained from cow udder quarters at different state of mastitis. Milk derived from infected udder quarters was characterised by a statistically significant higher total protein percentage share and a higher pH value ( $p \leq 0.05$ ) by a lower lactose ( $p \leq 0.01$ ) and casein content ( $p \leq 0.05$ ) than milk of healthy quarters. The content of solids not fat indicated the upward tendency and the content of total solids and vitamin C was reduced. The clinical mastitis caused reduction of milk yield by 33.63% and its components – by 24.11 to 52.20%. Mastitis was most often induced by the strains of *Staphylococcus aureus*. Different cows reaction to mastitis was observed.

**Key words:** mastitis, udder quarters, milk composition, losses.

### **INTRODUCTION**

Mastitis influences the total milk output and modifies its composition and technological usability. Results of comparative studies on composition and quality of milk received from the whole udder of healthy cows and cows with different mastitis progression are unequivocal. In his studies Kostyra [3] found out that higher mastitis progression causes higher fat content in milk but in Felańczak et al. [5] studies the results are contrary. Different results were also obtained in researches concerning changes in total protein content under the influence of mastitis. According to Gebler et al. [6] the content of this component can increase even up to 6% within some cows with acute mastitis or it can be only slightly changed as shown in the studies of Le Van et al. [4] and

Feleńczak et al. [5]. Contradictory opinions refer also to mastitis influence on the content of total solids in milk. An increase in the total solids content in milk obtained from cows with mastitis was observed by Groth et al. [8] and Danków [4], but Jurczak [11] claims that it may be significantly reduced with mastitis progression. Losses of milk caused by mastitis including separate udder quarters and disease progression were indicated in detail by Hryniewicz and Straś [10], Grajewski [7], Philipsson et al. [16] and Sender et al. [18], but the changes of quality and the content of particular milk components in this context were described in few works.

The objective of this study was to evaluate the yield, quality and composition of milk obtained from cows with mastitis and to estimate the losses of quantity and components of milk by comparison of infected and healthy quarters of the same cow.

## MATERIALS AND METHODS

The researches were carried out in the Warmia and Mazury Province in Autumn and Winter 1999/2000. Randomly selected Black-White cows with at least one healthy udder quarter and the others with different state of mastitis were the investigated material. Cows selection was performed on the basis of milk reaction with California mastitis test (CMT). The selected cows were in I – V lactation and were not treated for mastitis during the study. After precise milking separately of each udder quarter the obtained milk was weighed and milk samples were prepared. Samples of milk used in microbiological tests were also taken by milking each quarter directly into sterile tubes. A total of 186 milk samples derived from 56 cows were taken and analysed. The experimental material was divided into four groups indicating mastitis progression in separate quarters. Selection was based on the CMT result obtained from tests performed directly in the cowshed and confirmed by determination of somatic cells count (SCC) with Fossomatic 5000 apparatus. Symbols used in the CMT test results interpretation mark particular groups:

- (-) - samples of milk obtained from healthy quarters, treated as controls to which the results of other groups were compared – 93 samples of average SCC 178.97 thousand/ 1 mL.
- (+) - samples of udder quarters of low mastitis progression, result slightly positive - 28 samples of average SCC 695.36 thousand/ 1 mL.
- (++) - samples of udder quarters of mean mastitis progression, positive result – 34 samples of average SCC 2081.20 thousand/ 1 mL.
- (+++)- samples of udder quarters of high mastitis progression, result strongly positive – 31 samples of average SCC 6623.36 thousand/ 1 mL.

In the obtained milk samples the following determinants were performed: pH – with pH-meter, density – with thermolactodensimeter, content of five basic components – with Milkoscan 4000, casein content – by Pierow method modified by Czurina [3], total bacteria count with Bactoscan 8000S, vitamin C content by Tillmans [3] method. In each sample irrespective of udder quarters salubrity the kind of appearing microorganisms was determined.

The whole milk output and the percentage content of components were used to calculate the quantity (g) of components of milk obtained from experimental milking of particular udder quarters. The fat, total protein and casein yield was used to calculate the protein production index (PPI) and casein part index (CPI) by the following formulas:  $PPI = \text{protein, g} / \text{fat, g} \times 100$  and  $CPI = \text{casein, g} / \text{total protein, g} \times 100$ . The percentage loss of milk output and the loss of milk components quantity of infected udder quarters were calculated as compared to these of the healthy quarters of the same cows.

The analysis of variation in the non-orthogonal arrangement and the Duncan's test were carried out to determine means of traits for particular groups (x), coefficients of variation (v), and significance of differences between means of the analysed groups.

## RESULTS AND DISCUSSION

[Table 1](#) shows the results of milk traits value depending on mastitis progression. The influence of mastitis progression on milk density which ranged from 1.0285 to 1.0291g·cm<sup>-3</sup> with different udder quarters salubrity was not confirmed. However, statistically significant ( $p \leq 0.05$ ) influence of high mastitis progression (+++) on the increase in milk pH value to 6.86 was detected. Udder salubrity deterioration decreased the milk yield and variously influenced the percentage content of its components. The content of some milk components was on the same level as in milk obtained from the healthy quarters or was decreasing, other components content revealed the upward tendency with higher disease progression. Total solids and solids not fat percentage content in milk was not statistically significantly different while comparing infected and healthy quarters which is also confirmed in Gebler et al. [6] studies, however significant increase [8] or decrease in the total solids content [11] was reported in other studies. Milk obtained from highly infected quarters (+++) contained statistically significantly ( $p \leq 0.01$ ) lower lactose content than milk obtained from healthy and slightly infected quarters. An

increase in the total protein content in this milk was statistically significant ( $p \leq 0.05$ ) but only due to non-casein protein increase, because of statistically significant ( $p \leq 0.05$ ) decrease in the casein content. These changes in the protein content effected in statistically significant ( $p \leq 0.01$ ) reduction of casein part index (CPI) in the infected quarters. In milk obtained from infected udder quarters the lower fat content was detected. The low fat and high total protein content in milk of highly positive mastitis quarters caused the highest total protein production index (by more than 100%). Udder disease deterioration caused decrease in the vitamin C content in milk but differences between quarters with various mastitis progression were not significant.

**Table 1. Content of milk components depending on udder quarters salubrity**

Traits of milk	Udder quarters salubrity			
	(-)	(+)	(++)	(+++)
Density ( $\text{g} \cdot \text{cm}^{-3}$ )				
$\bar{X}$	1.0288	1.0291	1.0285	1.0279
sd	0.0026	0.0021	0.0031	0.0039
pH				
$\bar{X}$	6.61 <sup>b</sup>	6.56 <sup>b</sup>	6.64 <sup>b</sup>	6.86 <sup>a</sup>
sd	0.12	0.09	0.19	0.29
Milk (kg)				
$\bar{X}$	2.23 <sup>b</sup>	2.05 <sup>Ba</sup>	1.53 <sup>Ab</sup>	1.48 <sup>A</sup>
sd	0.88	0.84	0.54	0.79
Total solids (%)				
$\bar{X}$	12.35	12.20	12.34	12.12
sd	0.79	0.82	1.22	1.29
Solids not fat (%)				
$\bar{X}$	8.63	8.46	8.54	8.76
sd	0.50	0.46	0.71	1.01
Lactose (%)				
$\bar{X}$	4.92 <sup>b</sup>	4.88 <sup>b</sup>	4.46 <sup>b</sup>	3.51 <sup>A</sup>
sd	0.25	0.16	0.42	0.92
Fat (%)				
$\bar{X}$	3.72	3.74	3.79	3.36
sd	0.26	0.62	1.23	0.90
Total protein (%)				
$\bar{X}$	3.16 <sup>b</sup>	3.18 <sup>b</sup>	3.27 <sup>b</sup>	3.43 <sup>a</sup>
sd	0.25	0.25	0.30	0.42
Casein (%)				
$\bar{X}$	2.62 <sup>b</sup>	2.49 <sup>ab</sup>	2.37 <sup>a</sup>	2.34 <sup>a</sup>
sd	0.21	0.25	0.29	0.35
Vitamin C (mg %)				
$\bar{X}$	2.54	2.34	2.23	2.04
sd	0.23	0.46	0.50	0.56
Protein prod. Index (%)				
$\bar{X}$	84.94 <sup>b</sup>	85.02 <sup>b</sup>	86.28 <sup>ab</sup>	102.07 <sup>a</sup>
sd	29.04	21.10	35.71	39.09
Casein part index (%)				
$\bar{X}$	82.95 <sup>A</sup>	78.41 <sup>B</sup>	72.47 <sup>B</sup>	68.22 <sup>B</sup>
sd	3.94	3.95	4.29	9.65

Values in rows with different superscripts are significantly different at: A- $p \leq 0.01$  and A- $p \leq 0.05$ .

The obtained results of various influence of mastitis on milk quality are confirmed by other studies. Gebler et al. [6] and Kostyra et al. [13] found a significant lactose content decrease under the influence of mastitis but they also noted an increase in the fat content in the milk of cows with infected udders. According to other authors [1,

5] mastitis causes a decrease in the fat content in milk and in other studies [6, 17, 18, 20] the total protein content increase was observed in milk simultaneously with udder disease deterioration. The results of Felańczak et al. [5] researches prove that there are no equivocal changes in the content of this component under the influence of mastitis which is also confirmed in works of Haenlein et al. [9] and Le Van et al. [14] resulting in conclusion that the quantity of this component in milk does not depend on mastitis deterioration. The similar outcome can be found in the studies of Bastan et al. [2] informing that the value of correlation coefficient between the somatic cells count (SCC) and the total protein content was not significant. Todorova and Petrova [19] indicated significant changes of casein content under the influence of mastitis as well.

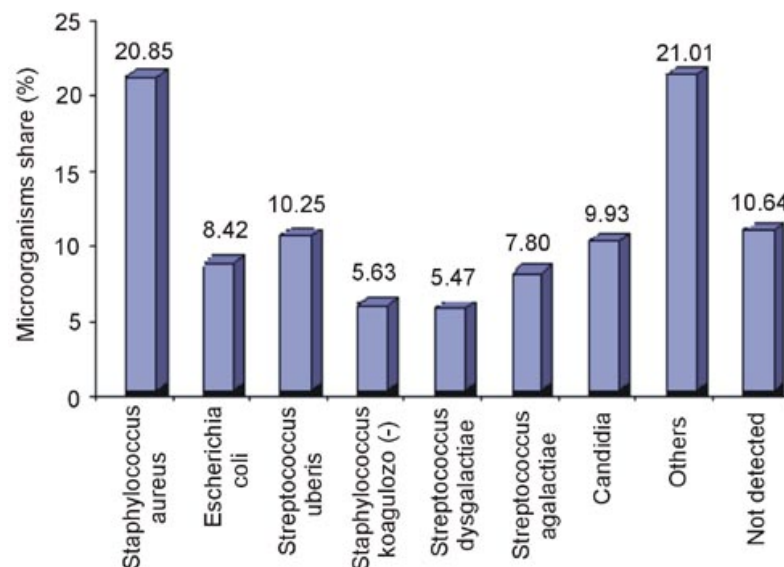
[Table 2](#) shows different reactions to mastitis in particular quarters. It was stated that in some quarters the content of total solids, solids not fat and total protein decreased even though the average content of these components increased. Generally the quantity of other milk components decreased under the influence of the disease although there were also some infected quarters in which the content of total solids, casein and fat increased. Strongly positive mastitis progression (+++) caused reduction in the lactose content in each infected quarter. Different cows reaction to mastitis can influence the level of the obtained results.

**Table 2. Percentage share of infected udder quarters with higher, equal and lower trait value in comparison with healthy quarters**

Traits of milk	Udder quarters salubrity and trait value								
	(+)			(++)			(+++)		
	higher	equal	lower	higher	equal	lower	higher	equal	lower
Yield of milk (kg)	41.67	8.33	50.00	21.42	0	78.58	9.33	6.23	84.4
Totals solids (%)	45.45	0	54.55	50.00	0	50.00	23.52	0	76.47
Solids not fat (%)	31.25	0	68.75	61.12	5.55	33.33	94.11	0	5.89
Lactose (%)	53.85	6.25	46.15	0	18.75	81.25	0	0	100.00
Fat (%)	21.43	0	78.57	26.47	0	73.53	32.26	0	67.74
Total protein (%)	41.67	0	58.33	68.75	6.25	52.00	88.58	7.14	4.28
Casein (%)	31.25	25.00	43.75	18.00	26.41	55.59	6.20	10.48	83.32

[Figure 1](#) shows the percentage share of particular microorganisms in milk of cows with induced mastitis, irrespective of mastitis progression. The obtained results indicate that mastitis was most often induced by *Staphylococcus aureus* (20.85%), but also by *Streptococcus* bacteria and yeast-like fungi (*Blastomycetes*) *Candida* sp. These results are similar to the outcome noted by other authors [12, 15]. The negative result of bacteriological test was obtained in 10.64% of highly positive (+++) CMT reaction and the visible macroscopic changes in milk. It is not the proof of the lack of pathogenic factor. It maybe the effect of suppurative state, the lack of microorganisms growth (bacteria sterile conditions) or *Mycoplasma* sp. existence causing mastitis but not growing on the standard media.

**Fig. 1. Type and share of pathogenic microorganisms causing mastitis**



**Table 3** shows the losses of milk yield and its components from udder quarters depending on mastitis progression. Disease deterioration of udder quarters caused decrease in the milk output. The loss of milk output in the low mastitis progression (+) accounted for 8.08% and did not reach the results obtained by Hryniewicz and Straś [10] – 23.4% under the same conditions. In the mean and high state of mastitis the losses of milk output reached 31.40 and 33.63% respectively. The particular milk components content was differentially reduced and losses depended on three factors: decrease of milk yield, percentage milk components share and the numbers of cows producing milk of lower or higher components content which depended on mastitis progression. In the low mastitis progression (+) the losses of the obtained components quantity, except total protein, were not higher than 10%, in the mean state of mastitis they were higher then 30% and the highest losses of lactose production (52.2%), fat (40%) and casein (36.78%) were observed in the clinical mastitis (+++).

**Table 3. Losses expressed as % of milk yield (kg) and its components (g) from udder quarters with different mastitis progression compared to milk yield from healthy quarters**

Traits of milk	Udder quarters salubrity				
	(-)		(+)	(++)	(+++)
	yield		yield losses		
	Kg and g	%	%	%	%
Milk (kg)					
$\bar{X}$	2.23	100.00	8.08	31.40	33.63
sd	0.88	-	1.69	10.88	12.28
Total solids (g)					
$\bar{X}$	274.51	100.00	8.90	31.23	34.66
sd	102.72	-	1.60	7.88	9.94
Solids not fat (g)					
$\bar{X}$	194.63	100.00	9.38	31.60	32.68
sd	71.45	-	1.56	7.46	8.93
Lactose (g)					
$\bar{X}$	109.72	100.00	8.82	37.78	52.20
sd	35.57	-	1.76	13.05	24.95
Fat (g)					
$\bar{X}$	82.88	100.00	10.94	30.03	40.00
sd	25.89	-	1.68	10.63	14.26
Total protein (g)					
$\bar{X}$	66.88	100.00	12.04	27.48	24.11
sd	25.68	-	2.45	8.01	6.57
Casein (g)					
$\bar{X}$	54.79	100.00	6.81	33.82	36.78
sd	17.09	-	1.03	9.56	10.48

## CONCLUSIONS

The conducted researches determined some changes caused by high mastitis progression of udder quarters with comparison to the healthy quarters of the same cows:

1. Percentage increase in the total protein content, protein production index and pH value.
2. Percentage decrease in the lactose and casein content and casein production index.
3. Tendency for increasing the solids not fat and decreasing the total solids and vitamin C content.
4. Milk yield decrease by 33.63% and its components by 24.11 to 52.20%.

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