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THE EFFECT OF MILKING SYSTEMS ON THE QUANTITY AND QUALITY OF COW MILK

Summary

The subject of the study refers to the effect of housing and milking systems on yield, chemical composition, and cytological quality of milk from primiparous cows held in two barns belonging to the same owner where cows were fed using the same feed. Cows from barn C were kept in deep litter and milked in a fishbone milking parlour, whereas cows from barn M were kept in box stalls with litter bedding and milked using milking robots manufactured by Lely. Data on 305-day lactation was collected from 82 cows in barn C and 246 primiparous cows in barn M. Primiparous cows from barn M showed better yields and better cytological quality of milk. Milk yield obtained during lactation in barn C was equal to 8,108 kg and in barn M – to 9,175 kg. Differences in kg milk yield, fat yield, and protein yield were statistically highly significant in favour of the herd in barn M. The percentage of milk samples with a somatic cell count (SCC) exceeding 400,000 per 1 ml was 10.5% for barn C and 2.5% for barn M. Percentage of milk samples of the highest quality, with an SCC lower than 100,000, was higher in barn M.

Key words: primiparous cow, milk, protein yield, somatic cell count, milking robot

WPLYW SYSTEMU DOJU NA ILOŚĆ I JAKOŚĆ MLEKA KRÓW

Streszczenie

Badano wpływ systemu utrzymania i doju na wydajność, skład chemiczny i jakość cytologiczną mleka krów pierwiastek w dwóch oborach należących do tego samego właściciela w których krowy żywiono tymi samymi paszami. W oborze C krowy utrzymywane były na głębokiej ściółce i dojone w hali „rybia ość”, w oborze M w boksach legowiskowych ścielonych i dojone robotami udojowymi firmy Lely. W oborze C uzyskano dane o 305 dniowej laktacji dla 82 krów, a w oborze M dla 246 pierwiastek. Pierwiastki w oborze M miały większą wydajność i lepszą jakość cytologiczną mleka. Wydajność za laktację w oborze C wyniosła 8108 kg, a w M 9175 kg. Różnice w wydajności kg mleka, tłuszczu i białka były statystycznie wysoko istotne na korzyść stada w oborze M. Procent prób mleka z liczbą komórek somatycznych (LKS) powyżej 400 tys. w ml w oborze C wyniósł 10,5%, a w oborze M 2,5%. Procent mleka o najwyższej jakości, poniżej 100 tys. w ml był wyższy w stadzie M.

Słowa kluczowe: krowa pierwiastka, mleko, wydajność białka, liczba komórek somatycznych, robot udojowy

1. Introduction

Profitability of milk production depends on factors such as milk yield and hygienic quality. Increase in milk yield is followed only by increase in direct costs, whereas indirect costs remain unaffected [14]. Milking frequency is one of the factors stimulating milk yield increase. This is valid for herds with milk yield of more than 8,000 kg of milk [2]. After switching from twice- to thrice-a-day milking, an increase in yield by 9 to 30% occurs [12, 14]. Further increase in milking frequency from three to four times a day results in subsequent increase in milk yield in cows [3, 6]. However, when milking frequency is increased in conventional barns, difficulties in work organisation emerge [12] and well-being of cows deteriorates due to shortened periods when cows lie and take in feed [3].

Milking robots used in modern barns greatly reduce the difficulties in work organisation and improve the well-being of cows.

Hygienic quality of milk is of crucial importance as it is the basic criterion used for determining its suitability for

consumption and trading. As of now, the main indicator of hygienic quality of milk is somatic cell count (SCC). It accurately reflects udder health in cows. Mastitis is a multifactorial disorder; one of the factors is irritation resulting from overmilking seen with conventional milkers [7].

On the other hand, overmilking is not present when milking robots are used, as pulsation is adjusted for each quarter individually – hence the name “individual-quarter milking”. It can be concluded from the literature that improvement in milk quality after implementing milking robots does not occur rapidly [4, 5, 11, 16].

The objective of the conducted study was to determine the effect of housing and milking systems on yield and hygienic quality of milk from primiparous cows.

2. Material and methods

The study was conducted in two barns belonging to the same owner. The barns were using different housing and milking systems (Table 1).

Table 1. Basic characteristics of cow housing, feeding, and milking systems used in the studied barns
 Tab. 1. Podstawowa charakterystyka systemu utrzymania, żywienia i doju krów w badanych oborach

System	Solution used in the barn	
	C – conventional	M – modern
Number of cows in the herd	140	320
Housing	– deep litter, 7.5 m ² per cow	– box stalls with litter bedding and grill feed alley floor; the floor cleaned by a Lely Discovery robot
Feeding		
– basic ration	– TMR – in two groups	– PMR – for the entire herd
– feeding	– Scariboldi feed wagon	– Scariboldi feed wagon
– feeding frequency	– twice a day	– thrice a day
– feed pushing	– skid steer pusher	– Lely Juno 100 robot
– concentrate feeding	---	– for all cows – at milking points, according to yields, – for cows with the highest yields – at a Lely feeding station, according to yields
Milking		
– type of milking equipment	– 2 x 9 fishbone milking parlour manufactured by Westfalia	– 4 Lely Astronaut A4 milking robots
– frequency	– twice a day	– individually adjusted

Source: own work / Źródło: opracowanie własne

In the old, conventional barn (C), cows were kept in deep litter and milked in a milking parlour manufactured by Westfalia. On the other hand, the new barn, commissioned in 2012, was equipped with litter box stalls and Lely milking robots.

Cows in both barns were black-and-white Polish Holstein-Friesian (PHF) cows of the same origin, distributed among the barns according to needs.

Feed was identical as well, came from the same fields, and was stored in the same place collectively.

The tests were conducted on cows calved in 2013, 2014, and 2015 that had 305 days of lactation. The collected information included data on 82 cows from barn C and data on 246 cows from barn M. Reference data used to compare yield results for cows in both barns were taken from a use value assessment conducted by the Polish Federation of Cattle Breeders and Dairy Farmers using the A 8 method

The following parameters were analysed:

- somatic cell count,
- milk, fat, and protein yield in kg,
- fat and protein content in milk.

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Cytological classification of milk (Table 2) was performed using a grading system recommended by the National Mastitis Council (NMC) and the Dairy Herd Improvement Association (DHIA).

Table 2. SCC grades of milk

Tab. 2. Klasy cytologiczne mleka

SCC grade	Somatic cell count in 1 ml – in thousands
1	up to 25
2	25.1 – 50
3	50.1 – 100
4	100.1 – 200
5	200.1 – 400
6	400.1 – 800
7	≥ 800.1

Source / Źródło: [9, 10]

3. Results and discussion

Yields reached by cows after 100 days of lactation were higher than mean values in Poland (Table 3). As far as values per day are concerned, the yield in cows from barn C was higher by 3 kg and in barn M – 7 kg higher than values reached by the general population of cows in Poland (P). Differences between the barns and the general population were also maintained in the second part of the 305-day lactation (Table 3). Differences in milk yields between herd C and herd M, both those noted after 100 and those noted after 305 days of lactation, were deemed statistically highly significant. As both studied herds were fed using the same mixed ration feed and the same feed wagon, the differences between them can only be attributed to milking frequency. Herd C was fed twice a day and gave lower yields, whereas milking frequency in herd M was adjusted individually for each cow based on stage of lactation and daily yield, and amounted to approx. 3 times a day.

Wolf and Jahnke [14] as well as Veuthier [16] noted even more pronounced differences in milk yields than those shown in Table 3 for twice-a-day and thrice-a-day milking. Fat and protein kg yields after both 100 and 305 days of lactation were also higher in cows from herd M compared to cows from herd C. Each of these differences was deemed to be statistically highly significant.

On the other hand, differences noted between herd C and herd M in the percentage of fat and protein content after each of the lactation periods were deemed to be statistically insignificant. It is important to note that protein content for both herds was higher than that for the general population of Polish cows – P (Table 3).

Protein content in milk of the general population of Polish cows after 100 days of lactation was very low – 3.07%, i. e. lower than 3.1%, the value considered to be the minimum value [1]. Protein content after 305 days of lactation was low as well – only 3.27%, i.e. slightly above 3.2%, the value considered to be the minimum value [17].

Low protein content in milk indicates low amount of energy in feed rations subsequently leading to low milk yield [8] in cows from the general population. In contrast, the cow feeding regime used in both studied barns was energetically correct (Table 3).

Table 3. Milk yield in primiparous cows after 100 and 305 days of lactation in the conventional barn and the modern barn
Tab. 3. Wydajność krów pierwiastek za 100 i 305 dni laktacji w oborze konwencjonalnej i nowoczesnej

Herd	Yields - kg			Content - %	
	milk	fat	protein	fat	protein
Absolute values					
After 100 days of lactation					
C	2994 ^A	112.7 ^A	97.5 ^A	3.84	3.32
M	3397 ^B	125.2 ^B	110.4 ^B	3.72	3.26
P	2697	105.0	83.0	3.88	3.07
After 305 days of lactation					
C	8108 ^A	326.5 ^A	282.5 ^A	4.00	3.49
M	9175 ^B	355.5 ^B	315.7 ^B	3.90	3.43
P	7390	293.0	242.0	3.96	3.27
Values as % of values reached by the general population (P)					
After 100 days of lactation					
C	111	107.3	117.5	99.0	108.1
M	126	119.2	133.0	95.9	106.2
P	100	100	100	100	100
After 305 days of lactation					
C	109.7	111.4	116.7	101.0	106.7
M	124.2	121.3	130.5	98.5	104.9
P	100	100	100	100	100

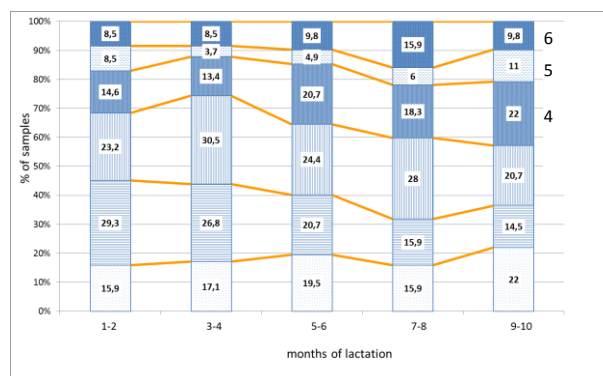
Source: own work / Źródło: opracowanie własne

Cytological quality is an important characteristic of milk. Only milk with an SCC of less than 400,000 per ml – i.e. an SCC grade of 1 through 5 – can be intended for consumption and processing. Milk with a higher SCC comes from cows with subclinical or clinical mastitis. It is a condition caused by many factors.

Therefore, preventive actions must be multidirectional. One of the factors leading to mastitis results from mechanical irritation of the glandular tissue of the udder caused by vacuum created in clusters during overmilking. Overmilking time for particular quarters of the udder depends on regularity of their growth. Selection of cows has been in progress for more than 50 years and the effects are not satisfying. Overmilking is eliminated in the so-called individual-quarter milking with robots.

In our study, the SCC of the milk of cows from barn C milked with standard clusters and cows from barn M milked with “individual-quarter” clusters of milking robots were compared.

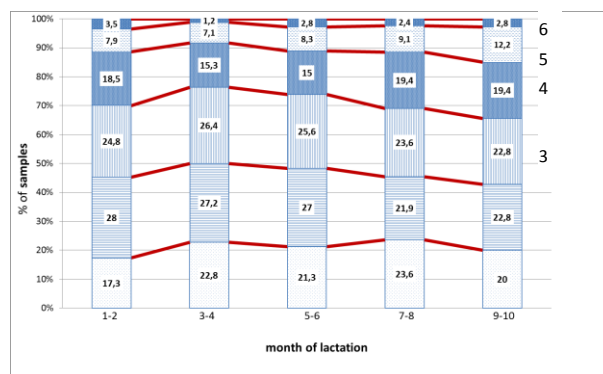
After implementing automatic milking, one should expect an improvement in cytological quality of milk. However, experience shows that it does not occur immediately and the quality even temporarily aggravates [4, 5, 11, 13, 16]. Distribution of milk samples between SCC grades in the course of lactation has been shown in Figure 1 (for barn C) and Figure 2 (for barn M).



Source: own work / Źródło: opracowanie własne

Fig. 1. Distribution of milk samples collected from primiparous cows between SCC grades in particular months of lactation in barn C

Rys. 1. Rozkład prób mleka, od krów pierwiastek, w klasach cytologicznych, w miesiącach laktacji w oborze C.



Source: own work / Źródło: opracowanie własne

Fig. 2. Distribution of milk samples collected from primiparous cows between SCC grades in particular months of lactation in barn M

Rys. 2. Rozkład prób mleka, od krów pierwiastek, w klasach cytologicznych, w miesiącach laktacji w oborze M

At the beginning of the lactation period, milk samples indicating mastitis, i.e. samples with grade 6 or higher, were collected from 8.5% of cows from the herd in barn C. During the 7th and 8th month, it increased to 15.9%, while in the last stage it decreased and was equal to 9.8%. In barn M, the same percentage was much lower during the entire lactation period. At the beginning, it was only 3.5%, then it was slightly lower, and at the end of lactation, it affected only 2.8% of cows.

At the beginning of lactation, milk samples of the highest quality – having 100,000 somatic cells in 1 ml at most, i.e. grade 1, 2 or 3 samples, were collected from 68.4% of cows in barn C. In the 3rd and 4th month, it increased to 74.4%, then it was gradually decreasing, and in the last stage of lactation, it reached 57.2% of cows. In barn M, the same percentage was established to be 70.1% at the beginning of lactation and was very similar to that recorded in

barn C. As for the 3rd and 4th month of lactation, the difference between the two barns was minute as well – 2% in favour of barn M. At the end stage of lactation, the difference between both herds became deeper and reached 8.4%.

Geometric mean SCC during lactation (Table 4) is the next proof of better conditions in respect of udder health in barn M compared to barn C.

Table 4. Geometric mean SCC of milk in primiparous cows from the studied barns during lactation

Tab. 4. Średnia geometryczna LKS za laktacje u krów – pierwiastek w badanych oborach

SCC grade	Number of cows in barn		Percentage of cows in barn	
	C	M	C	M
1	10	34	12.2	13.8
2	17	75	20.7	30.5
3	28	73	34.1	29.7
4	15	41	18.3	16.7
5	8	23	9.8	9.3
≥6	4	-	4.9	-
Total	82	246	100	100

Source: own work / Źródło: opracowanie własne

In four cows (4.9%) from barn C mastitis was persistent during the entire lactation period, whereas in barn M mastitis was not observed in cows. On the other hand, more cows from barn M (74%) than from barn C (67%) gave highest quality milk (less than 100,000 somatic cells per 1 ml).

The presented results indicate a similar course of changes in SCC levels during lactation for both barns, which is expressed in the following observations:

- percentage of cows with mastitis was nearly the same at the beginning and at the end of lactation,
- the highest percentage of grade 1, 2, and 3 milk was reached during the 3rd-4th month of lactation and was then gradually declining until the end of lactation.

In contrast, the obtained results indicate that milk from cows in barn M had better cytological quality than milk from cows in barn C (Figures 1 and 2). This conclusion is supported by:

- a much lower percentage of cows with mastitis,
- the percentage of milk of the highest quality (less than 100,000 somatic cells in 1 ml) higher by ca. 10% in the period between the beginning of the 5th month of lactation and the end of lactation,
- the fact that there were no cows that gave milk classified as grade 6 or higher based on the geometric mean SCC.

Contrary to a number of studies [4, 5, 11, 13, 16], our research revealed that cytological quality of milk improved from the very beginning after implementing a milking robot. The difference in results is conditional on methodological premises. The authors listed above had analysed the SCC in entire herds, i.e. SCC in the milk of cows in different lactation conditions. On the other hand, our study included only primiparous cows. It made it possible to exclude factors having after-effects, such as past udder health, duration of dry period of the previous lactation, etc.

4. Conclusion

The conducted analysis of milk yield and cytological and chemical quality of milk in two herds kept using differing milking and housing systems leads to the conclusion that robot-milked primiparous cows:

- showed statistically significantly higher kg milk, fat, and protein yields, which can be attributed to increased milking frequency,
- attained better cytological quality of milk, which indicates good udder health. It can be assumed that milk quality was affected by strict adherence to principles of milking physiology and hygiene, including the elimination of over-milking,
- and that percentage of fat and protein content in milk did not depend on the milking system used.

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