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COMPARISON OF TWO METHODS OF HOUSING PRIMIPAROUS COWS*

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Abstract

We researched the influence of two methods of housing primiparous cows on meeting estimated energy requirements. In herd A primiparous cows were kept in a separate technological group during the whole lactation period, whereas in herd B they were kept in technological groups together with multigravid cows. The whole herd A consisted of 400 cows, where the average annual yield was 10,200 kg of milk per cow. Herd B consisted of 250 cows, where the average annual yield was 8,500 kg of milk per cow. In 2010 and 2011 there were 200 primiparous cows in herd A, whereas in herd B there were 165 primiparous cows. The milk yield for 100 and 305 days of lactation was analysed. Meeting the cows' demand for energy was determined on the basis of the percentage of protein in milk. In both herds primiparous cows were divided into milk yield classes for 100 days of lactation. Both the trend and the amount of variation in the content of protein in milk were found to be identical in both herds. The content of protein in milk increased as the milk yield decreased. This regularity could be observed at both lactation stages under analysis and the differences between the classes were statistically confirmed. During the first 100 days of lactation the estimated energy deficit comprised a much larger percentage of the cows than in the 305-day lactation period. The system of maintenance of primiparous cows (separately or together with multigravid cows) was not found to influence the milk yield or the estimated demand for energy.

Key words: primiparous cow, housing system, milk yield, energy demand

Recent years have seen significant changes in milk production in Poland. There have been structural changes taking place along with a gradual slight decrease in the population of cows and increase in the overall amount of milk produced. On the one hand, the number of larger herds has been systematically increasing and on the other

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hand, the individual yield per cow has been increasing. As results from the data of the Polish Federation of Cattle Breeders and Dairy Farmers (PFHBiPM, 2013), in the Wielkopolskie Voivodeship the number of herds with 50 or more cows increased from 466 in 2009 to 518 in 2012. The research by Winnicki et al. (2012) proved that in 69.2% of herds the loose housing system prevails. In this system there is a higher risk of malnutrition of the cows which are at the bottom of the herd hierarchy, especially primiparous cows, than in the tie-stall system (Kolb, 1987).

In 2012 in Poland the average annual yield of cows under milk recording was 7,396 kg, whereas in the Wielkopolskie Voivodeship it was 8,132 kg. Simultaneously, the number of herds where the annual milk yield exceeds 10,000 kg is increasing. In 2012 there were 173 such herds in the Wielkopolskie Voivodeship, with the total cow population of 19,000 (PFHBiPM, 2013). As the cows milk yield increases, there is a greater risk of energy deficit in cows. This phenomenon is usually related with the period around the peak of lactation (Reklewski, 2008). Beerda et al. (2007) note the great risk of negative energy balance in primiparous cows. The diversification of the milk yield in a herd requires various nutritional rations in terms of the composition, the content of energy, protein, vitamins and mineral components in a kilogram of dry matter.

At present two principal feed allocation systems are applied in free-stall cowsheds:

PMR – high yielding cows are nourished at a feed station. It is possible to feed several types of feed mixtures from one station. This solution is effective in smaller herds.

TMR – the herd is divided into technological and nutritional groups. Each group receives a different kind of TMR. This variant is chiefly used in larger herds, where primiparous cows are bred in a separate technological group. We have not found results of studies on the effectiveness of this solution in the available zootechnical reference publications. This is a problem of high practical significance, both in conventional milking – in a milking parlour and in milking with a multi-stall robot.

The aim of the study was to determine how the housing system of primiparous cows, in a separate group or together with multigravid cows, would influence their milk yield and meeting the estimated demand for energy. We assumed that due to the fact that primiparous cows are lighter than multigravid cows and they have a lower position in the herd hierarchy, they may have problems receiving the sufficient amount of nutrients with feed, including energy nutrients, and as a result, they may be malnourished. Apart from that we analysed if the milk yield of primiparous cows during the first 100 days after calving will influence the estimated satisfaction of their energy demand in the initial and 305-day period of lactation.

Material and methods

The research was carried out in the Wielkopolskie Voivodeship, in two farms (herds) breeding Polish Holstein-Friesian cattle, which differed in their systems of

housing and feeding of primiparous cows (Table 1). In both farms the share of primiparous cows in the herd structure was 35–36%.

Table 1. The scheme of the experiment

Herd	Technology and nutrition group	Group symbol	Number of cows in group	TMR set for milk yield (kg·day^{-1})
A	primiparous cows only	-	up to 112	30
B	primiparous cows together with multigravid cows	B-1	90 – 110	40
		B-2	45 – 65	28
		B-3	45 – 55	20

In farm A primiparous cows were kept in a separate group during the entire period of lactation and they were fed *ad libitum* with a total mixed ration (TMR), which was set for an identical milk yield of 30 kg per day for all the animals.

In farm B primiparous cows were kept together with multigravid cows in three technological groups, which differed in the milk yield, and the animals were fed *ad libitum* with different (depending on the average milk yield in the group) feed rations (TMR).

In both herds TMRs consisted of similar roughages and concentrate feeds, typical of the Wielkopolskie Voivodeship. The basic concentrate feed in TMRs consisted of whole-crop maize silage and wilted alfalfa or grass silage, supplemented with beet pulp silage, brewer's grain silage and straw. The TMR also consisted of lactation concentrate mixture, which was composed of extracted soybean and rapeseed meal, rapeseed oil cake and the additives of vitamins, minerals and buffering agents. Feed rations for the cows were determined by a nutritionist. In order to balance the feed rations the Dutch DVE/OEB system was used together with SynchoFOS – the extended version of FeedExpert computer software. Feed was supplied twice a day. Before a new portion of feed was supplied leftovers had been removed. They made about 5% of the amount of feed supplied.

Table 2 shows the basic characteristics of feed rations for individual groups of cows.

Table 2. The basic characteristics of TMRs in individual nutritional groups of cows

TMR parameter in reference to dry matter (DM)	Herd – group			
	A	B		
		B-1	B-2	B-3
Content (%)	47	48	45	42
Content of total protein (TP) (g·kg^{-1})	170	160	145	130
Energy concentration (MJ·kg^{-1})	6.8	7.0	6.4	6.1
Percentage of concentrate feeds	42	39	24	15

The effectiveness of the housing and feeding system was analysed on the basis of the results of the performance recording carried out with the A4 method (PFHBiPM Poznań Assessment Region 2011 and 2012) for 2010 and 2011.

The degree of energy security guaranteed with the feed supplied to cows was assessed on the basis of the percentage of protein in milk (Krzyżewski et al., 1997), assuming that if the feed ration was correctly balanced, the content of protein should be adequate to the cows breed and stage of lactation. The results were interpreted according to Ziemiński and Juszczak's (1997) scale of the content of protein in milk for Polish Holstein-Friesian (PHF) cows. Brade and Brade's (2010) scheme was used for analysis of the content of protein at different stages of lactation. In both cowsheds the cows were kept in the free-stall system. Cowshed A was equipped with litter stall beds, where once a day faeces were removed from the solid concrete floor with a bulldozer. In cowshed B there were deep-litter stall beds. There was a solid concrete floor in the feed corridor. Faeces were removed with a delta scraper six times a day. In both cowsheds drinking troughs were used.

In farm A there were 112 stalls in the cowshed section for primiparous cows. It was four times more than the number of stalls in the milking parlour. In farm B the number of animals in technological groups varied according to the cows' physiological status and their milk yield. However, this did not disturb the milking process when the autotandem milking parlour with $2 \times 3 + 1 = 7$ stalls was used. The cows were milked twice a day in both cowsheds.

In farm A the average annual milk yield per cow was more than 10,000 kg, whereas in farm B it was over 8,000 kg of milk (Table 3). The milk yield in both farms was higher than the average yield from PHF cows in the Wielkopolskie Voivodeship.

Table 3. The average milk yield in herds*

Herd	Year	Average number of cows	Milk (kg)	Average yield			
				fat		protein	
				kg	%	kg	%
A	2010	389.1	10143	401	3.95	345	3.40
	2011	411.7	10273	391	3.81	343	3.34
B	2010	237.8	8276	369	4.46	286	3.45
	2011	236.3	8664	365	4.22	294	3.39
Wielkopolskie Voivodeship	2010	118225.1	7677	319	4.15	260	3.39
	2011	121060.0	7949	322	4.05	267	3.36

*According to the annual report of PFHB and PH – Poznań Assessment Region for 2010 and 2011.

The study is an analysis of the milk, fat and protein yield from primiparous cows during 100 and 305 days of lactation, including the percentage of fat and protein in milk. Altogether, data about 200 primiparous cows from herd A and 165 primiparous cows from herd B were collected.

The method of one-way analysis of variance for non-orthogonal systems was used to compare differences between the groups. If there were significant differences between all the items, the differences in pairs of mean values for the items were tested with the least significant differences (LSD) (Harabasz and Ceranka, 1977).

Results

Table 4 shows the production results of primiparous cows during 100 and 305 days of lactation. In both farms under investigation the yield of milk, fat and protein was higher than the corresponding average values of the population of primiparous cows in the Wielkopolskie Voivodeship. The differences observed in both herds were smaller for the 100-day period and greater for the 305-day period of lactation.

Table 4. The production indexes of primiparous cows in both herds

Herd	Lactation period (days)	Statistical index*	Yield (kg)			Content (%)	
			milk	fat	protein	fat	protein
A	100	$\bar{x}$	3139	120.8	99.1	3.87	3.17
		SD	483	19.3	13.2	0.41	0.19
		V_x	15	16	13	11	6
	305	$\bar{x}$	9081	340.9	301.6	3.79	3.33
		SD	1516	51.8	45.1	0.41	0.20
		V_x	16	15	15	11	6
B	100	$\bar{x}$	2825	124.6	90.5	4.42	3.23
		SD	593	29.2	17.0	0.51	0.23
		V_x	21	23	19	12	7
	305	$\bar{x}$	8163	350.3	274.5	4.32	3.38
		SD	1762	73.5	53.9	0.51	0.21
		V_x	22	21	20	12	6
Wielkopolskie	100	$\bar{x}$	2765	108	85	3.90	3.08
Voivodeship	301	$\bar{x}$	7562	298	249	3.94	3.29

* $\bar{x}$ – mean; SD – standard deviation; V_x – coefficient of variation.

The yield of milk and protein (kg) of primiparous cows was higher in farm A than in farm B. The difference in daily milk yield between the farms (about 3 kg) could be seen during the whole period of lactation. The lactation persistency was good in both farms, because the difference in the daily milk yield for the first 100 and 305 days was slightly greater than 2 kg. During both periods of lactation the fat yield was higher in farm B than in farm A and the percentage of fat in the milk from primiparous cows in herd B was about 0.5% higher than in herd A. During both periods of lactation the content of protein in the milk of primiparous cows from herd B was about 0.05% higher than in the milk from herd A.

The variation in the yield of milk, fat and protein in herd B (about 20%) was higher than in herd A (about 15%). There was a similar but much smaller variation in the percentage of fat (11–12%), and the smallest variation in the content of protein (6–7%) in milk.

Due to the diversified average milk yield in both herds we decided to estimate the degree to which the energy demand of primiparous cows is met depending on their milk yield during the first 100 days of lactation.

Table 5. The number of primiparous cows in groups categorised according to the milk yield during the first 100 days of lactation

Class	Yield for 100 days (thousand kg)	Number of cows in herd		Percentage of cows in herd (%)	
		A	B	A	B
1	>3.5	37	18	18.5	10.9
2	3–3.5	89	53	44.5	32.1
3	2.5–3	50	46	25.0	27.9
4	2.0–2.5	24	29	12.0	17.6
5	<2.0	0	19	0	11.5
Total:		200	165	100	100

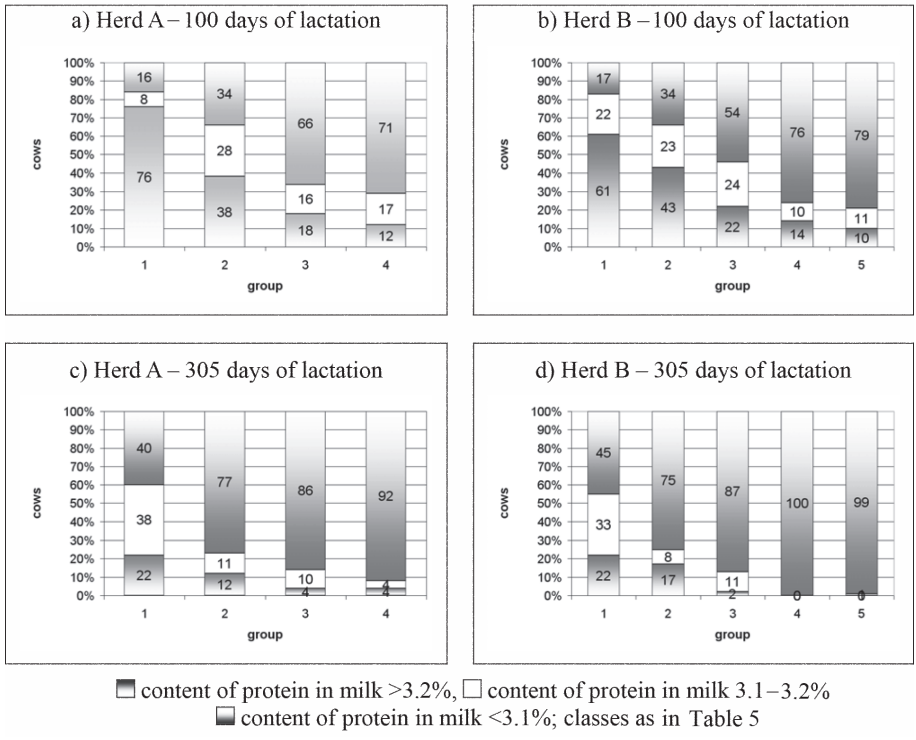

Figure 1. The percentage of cows according to the content of protein in milk depending on the milk yield during the first 100 and 305 days of lactation

Figure 1 shows the percentage of primiparous cows in both herds according to the content of protein in milk for 100 and 305 days of lactation in individual yield classes.

As results from the table, in both herds there was the highest share of primiparous cows from class 2, where the milk yield ranged from 3,000 to 3,500 kg. However, the percentage of individual yield classes in both herds was diversified. In herd A

there was a much higher share of the primiparous cows which yielded more than 3,000 kg of milk (class 1 and 2). Altogether they formed 63% of the herd, whereas in herd B only 43% of primiparous cows belonged to this yield class. On the other hand, in herd B there was a much higher share (29.1%) of the primiparous cows which yielded less than 2,500 kg of milk (class 4 and 5), whereas in herd A the share of such primiparous cows amounted only to 12% of the herd (class 4).

During the first 100 days of lactation there were 16% of the cows from herd A in yield class 1, whereas in the corresponding yield class in herd B there were 17% of the cows whose milk had greater content of protein than 3.2% (Figures 1 a and 1 b). In yield class 2 in both herds the share of such cows doubled and reached 34%. In the consecutive yield classes there was a further successive increase in the share of the cows whose milk had greater content of protein than 3.2%.

There was a similar variation in the percentage of cows in terms of the content of protein in milk during the 305-day lactation, but the proportions were different. There was a much higher percentage of the cows whose milk had greater content of protein than 3.2% and there was a lower percentage of the cows whose milk had less protein than 3.1%. In comparison with the first period of lactation, where the primiparous cows of yield group 2 with the 3.2% content of protein in milk formed 34%, during the 305-day lactation the share of such cows increased to 77% in herd A (Figure 1c) and to 75% in herd B (Figure 1 d).

As a result of the division of primiparous cows within their herds into milk yield classes for 100 days of lactation the mean values between the herds levelled off (Table 6). This enabled the comparison of individual milk yield classes from both herds with each other.

Table 6. The mean productive values of primiparous cows in the milk yield classes for 100 days of lactation

Herd days of lactation	Class	Mean yield (kg)			Mean content (%)	
		milk	fat	protein	fat	protein
A	1	3871	138.5	116.7	3.58	3.02
100 days	2	3244	127.4	101.9	3.93	3.14
	3	2805	110.7	91.4	3.95	3.26
	4	2377	90.6	78.4	3.79	3.27
B	1	3753	162.9	114.6	4.35	3.06
100 days	2	3254	141.3	101.9	4.34	3.13
	3	2750	124.9	88.9	4.54	3.24
	4	2344	104.0	78.0	4.43	3.32
	5	1858	81.6	63.3	4.38	3.40
A	1	11180	394.0	358.1	3.53	3.20
305 days	2	9312	349.6	307.8	3.77	3.31
	3	8126	318.5	277.5	3.93	3.42
	4	7279	279.7	249.8	3.85	3.44
B	1	10686	427.8	343.9	4.02	3.32
305 days	2	9442	395.0	312.6	4.19	3.31
	3	7860	351.5	267.3	4.48	3.40
	4	6839	302.3	236.6	4.43	3.46
	5	5487	243.4	192.4	4.43	3.50

As can be seen from the table, regardless of the stage of lactation in both herds, the cows' milk yield decreased with a successive increase in the percentage of protein in milk. However, the differences between the extreme yield groups ranged from 0.24% to 0.34% during the 100-day lactation and from 0.18% to 0.24% during the 305-day lactation. In the corresponding yield groups the content of protein in milk was very similar and there were minimal differences between the herds.

In both herds no direct correlation between the milk yield and the percentage of fat in milk was observed either during the 100-day or the 305-day lactation. During the lactation periods under analysis in all of the yield groups the content and yield of fat in the milk from the cows in herd B was greater than in herd A.

Table 7. The content of protein in the milk of the cows from herd A according to the yield classes and differences between the classes

Lactation period (days)	Class	Mean content of protein (%)	Difference between classes		
			1	2	3
100	1	3.02	-	-	-
	2	3.14	0.12xx	-	-
	3	3.26	0.24xx	0.12xx	-
	4	3.27	0.25xx	0.13xx	0.01ns
305	1	3.20	-	-	-
	2	3.31	0.11xx	-	-
	3	3.42	0.22xx	0.11xx	-
	4	3.44	0.24xx	0.13xx	0.02ns

ns – statistically insignificant differences (P>0.05).
x – significant differences between values (P≤0.05).
xx – highly significant differences between values (P≤0.01).

Table 8. The content of protein in the milk of the cows from herd B according to the yield classes and differences between the classes

Lactation period (days)	Class	Mean content of protein (%)	Difference between classes			
			1	2	3	4
100	1	3.06	-	-	-	-
	2	3.13	0.07xx	-	-	-
	3	3.24	0.18xx	0.11xx	-	-
	4	3.32	0.26xx	0.19xx	0.08ns	-
	5	3.40	0.34xx	0.23xx	0.16xx	0.08ns
305	1	3.22	-	-	-	-
	2	3.31	0.09ns	-	-	-
	3	3.40	0.18xx	0.09x	-	-
	4	3.46	0.24xx	0.15xx	0.06ns	-
	5	3.50	0.28xx	0.19xx	0.10ns	0.04ns

ns – statistically insignificant differences (P>0.05).
x – significant differences between values (P≤0.05).
xx – highly significant differences between values (P≤0.01).

Table 7 shows the mean content of protein in the milk from the cows in herd A according to the yield groups. The differences between classes 1, 2 and 3 in

both lactation periods under analysis proved to be statistically highly significant ($P \leq 0.01$), whereas the differences between classes 3 and 4 proved to be insignificant ($P > 0.05$).

Table 8 shows the corresponding values for the cows from herd B. Also in this herd in most cases in both lactation periods under analysis the differences between the classes proved to be statistically significant ($P \leq 0.01$ or $P \leq 0.05$), especially in the higher yield classes, whereas they proved to be insignificant ($P > 0.05$) in the lower yield classes.

Discussion

The problem of feeding cows during the transitional period and the period around the peak of lactation has been the subject of numerous studies (Drackley, 1999; Stevenson, 2001; Nowak et al., 2003; Osięgłowski and Strzetelski, 2006; Strzetelski et al., 2008). The decrease in the negative energy balance in cows was proved to be significantly affected by the stimulation of appetite and correctly balanced nourishment rations as well as by the application of feed additives stabilising fermentation in the rumen during the early period of lactation when it is necessary to supply large rations of concentrate feeds. The new generation of feed additives, including exogenous fibrolytic enzymes, may also play an important role in meeting the dairy cows' demand for energy during lactation and in regulation of the digestive processes in the rumen (Bilik and Łopuszańska-Rusek, 2009, 2010). The studies by Heuer et al. (2000), Schei et al. (2005) and Morel et al. (2010) proved that the degree to which the demand for energy and protein is met in dairy cows during lactation has an effect on the milk yield and the content of protein in milk. Brun-Lafleur et al. (2010) also observed that the reaction of primiparous cows to the feeding standard applied during lactation was more noticeable than in multigravid cows. Other studies (Bossen et al., 2009) proved that the feeding standard during lactation has influence not only on the yield and chemical composition of milk but also on cows' weight and body condition. These conditions and correlations are particularly noticeable in primiparous cows, which increase their body weight in the natural life cycle.

Our own research proved that the average yield from primiparous cows in both herds was higher than the average milk yield from cows of the same breed in the Wielkopolskie Voivodeship (PFHB i PM, 2011 and 2012). This fact proves that these animals have higher productive potential, the breeding work is well done and there are appropriate conditions of animal nourishment, maintenance and care. This particularly applies to herd A, where the milk yield of primiparous cows was about 10% greater than in herd B and about 20% greater than the average yield of primiparous cows in the Wielkopolskie Voivodeship. However, the comparison of the milk yield of primiparous cows with the whole herd of cows revealed that in herd B the yield of primiparous cows was about 5% lower and in herd A it was about 10% lower than the average yield of the whole herd. In both herds the content of fat and protein in the milk of primiparous cows was very similar to the mean content of these components

in the milk of the cows from the whole herd. The milk yield of primiparous cows in herd B, which was only slightly lower than the yield of the whole herd, points to the fact that these animals can be kept in multi-stall cowsheds together with multigravid cows in the same technological groups. The absence of contraindications to keeping primiparous cows together with multigravid cows is also proved by the production indexes of 29 primiparous cows in herd B, whose milk yield during the 305-day lactation exceeded 10,000 kg and was higher than the average milk productivity in the whole herd during the lactation period under analysis. Simultaneously, these data show that keeping primiparous cows together with older cows does not have significant influence on the production indexes obtained in free-stall cowsheds.

A similar percentage of cows in terms of the content of protein in milk was found in both herds in the groups with a similar milk yield. Also, there was a noticeable tendency for the lower content of this component in the higher yield classes. These facts prove the problem of energy deficit in high milk yield cows during the early stage of lactation, which is known from zootechnical literature (Brade and Brade, 2011; Reklewski, 2008; Krzyżewski et al., 1997). The phenomenon is more intense in higher milk yield cows (Engelhard, 2009).

Our own research also enabled us to estimate the degree of probable energy deficit depending on the yield and stage of lactation. When the milk yield was higher than 3,500 kg during the first 100 days of lactation, the energy deficit estimated on the basis of the percentage of protein in milk applied to about 85% of primiparous cows at the initial stage of lactation, whereas it applied to 60% of the animals during the 305-day lactation. When the milk yield ranged from 3,000 to 3,500 kg, the corresponding values were 65% and 25%, respectively. The lower milk yield of primiparous cows at the initial stage of lactation determines the lower range of occurrence of the energy deficit in those cows at both stages of lactation. There was an identical intensity of this regularity observed in both housing systems of primiparous cows.

To sum up, we can conclude that the level of milk yield from primiparous cows during the first 100 days of lactation may influence the incidence of the energy deficit during the entire 305-day lactation. At the same time, the research findings point to the fact that the housing system of primiparous cows, separately or together with multigravid cows, does not have significant influence on the content of protein in milk and the cows' energy deficit, which is estimated on this basis. Therefore, there are no contraindications to the system of housing primiparous cows together with multigravid cows in one technological group in the breeding practice of free-stall dairy farms.

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