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PRODUCTIVITY OF COWS FED WITH TMR SYSTEM CALVED IN DIFFERENT SEASONS

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Abstract. The aim of this study was to assess the influence of calving season on the milk yield and course of lactation of cows fed with Total Mixed Ration system. The study was conducted in herd of 220 cows of Polish Holstein-Friesian breed of Black and White variety (PHF-HO) with an average milk yield exceeding 8 000 kg. It was determined that the calving season influenced the milk yield, its chemical composition and shape of lactation curves. It was demonstrated that calving in the winter months was the least favorable, due to lower productivity in the complete lactation. Births in this season initiated lactations characterized by the lowest daily milk yield in the lactation peak as well as in the last months of lactation. The highest daily milk yield in early lactation, concomitant with the most advantageous milk composition to the 5th-6th month, was associated with autumn calving, which, however, occurred with the lowest frequency.

Keywords: calving season, cows, milk yield and composition, Total Mixed Ration

INTRODUCTION

The genetic development occurring within dairy cattle breeding has increased the genetic potential of animals and concomitantly forced certain changes in animal nutrition and feeding techniques. Highly productive cows should be fed with stable doses, without rapid changes of fodder. The failure to follow this regimen leads to deterioration of animal productivity and contributes to metabolic disorders, and consequently also has influence on the reproductive indices [Mroczek 2006]. Total Mixed Ration system (TMR) is the most recommended system of cattle feeding due to the nature of changes of feed components in the digestion process. The TMR consists of preparing a mixture of roughage, concentrated feed and mineral substances and feeding it as the complete feeding dose, which is available to animals throughout 24 hours. The composition of such mixture is adjusted to the nutritional requirements of cows in certain production cycle and allows using the same sets of fodder for a prolonged time [Podkówka and Podkówka 2004, Szarkowski et al. 2009].

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Calving season has been mentioned as one of the non-genetic factors of influence on the productivity of dairy cows. This factor, similarly to the production season, was indirectly associated with animal nutrition. Before the introduction of the TMR system, the nutrition on many farms was determined by the seasonal supply of fodder [Litwińczuk and Szulc 2005]. The significant impact of calving season on the milk yield of cows was determined in numerous studies [Sobczyńska 1989, Polański et al. 1992, Borkowska et al. 1993, Borkowska 1995]. The most frequent observation was that the most favorable calving season (in regard to the milk production) was the period autumn-winter, whereas the summer season was the least beneficial. Furthermore, it was also determined [Kuczaj 2004, Szewczuk et al. 2011] that the calving season had a significant influence on the calf development. Research of Kuczaj [2004] indicated that calves born in the winter season were characterized by the best development in the first days of life. Szewczuk et al. [2011] reported that the greatest rates of daily weight gain throughout the rearing period were characteristic of heifers born in winter (704 g) and bulls born in spring (750 g). Nonetheless, no significant effect of calving season on the cow fertility was stated [Jankowska 2002].

Only few studies concerning the effect of calving season on the cow productivity have been published in last several years. During this period fundamental changes have been made in the system for maintenance and feeding techniques for dairy cows. Therefore, the objective of the present study was to assess the impact of calving season on the productivity in lactation of cows fed with TMR system. The changes of productivity and milk composition in the course of lactation of cows calved in different seasons were also investigated.

MATERIALS AND METHODS

The study was conducted in years 2005–2009 in a herd of 220 cows of Polish Holstein-Friesian breed of Black and White variety (PHF-HO), with an average milk yield exceeding 8 000 kg. Animals were maintained in free-stall deep-bedded barns and fed with TMR system. Cows were divided into 9 technological groups. The TMR mixture throughout the experimental period consisted of silage of grass, alfalfa and maize; hay; brewer's grain and concentrated feed (extruded soybean and rapeseed meal and crushed cereal meal – barley, wheat and corn) and feed supplements, for which addition and proportion in the dose were determined by the milk yield and stage after calving.

The study data were derived from RW-2 reports. They comprised the results of 12,216 samples from test-day milking and 1,013 lactations. Daily and lactation milk yield (kg) were converted into FPCM yield (fat and protein corrected milk) according to the following formula [Subnel et al. 1994]:

$$\text{FPCM (kg)} = [0.337 + 0.116 \times \text{fat (\%)} + 0.06 \times \text{protein (\%)}] \times \text{milk (kg)}$$

The data were analyzed statistically in SAS software [SAS® User's Guide 2006]. The statistical model included the effect of calving season (following seasons were distin-

guished: spring – March, April, May; summer – June, July, August; autumn – September, October, November; and winter – December, January, February) and subsequent month of lactation (1th, 2nd, 3rd, ... , 10th and 11th and further months) and the interaction between these factors. The significance of differences between means was estimated with Duncan's test.

RESULTS AND DISCUSSION

The least number of births from analyzed 1013 births was in months from September to November (171, which accounted for 16.9%). The number and proportion of births in other seasons were similar (in a range of 27.6–27.7%) – Table 1. The lower percentage of cows calving in the autumn season is also indicated by other studies [Borkowska 1995, Borkowska and Januś 2004]. The longest (393 days) lactations were those initiated in the spring season. In case of calving in months from June to August, lactations lasted 24 days shorter (difference significant at $P \leq 0.01$). Significant ($P \leq 0.05$) differences between spring and autumn and winter calving date were also recorded in regard to the lactation duration. The shortest lactations were accompanied by the highest actual milk yield (8671 kg) as well as converted to FPCM yield (8702 kg). Births in summer season proved to be the most advantageous in terms of FPCM yield, calculated to one-day of standard lactation (25.5 kg) and complete lactation (23.6 kg). The lowest milk yield in complete lactation was observed in case of winter calving. The difference between the highest (summer calving season) and the lowest milk yield (winter calving season) was statistically significant ($P \leq 0.05$) and accounted for 673 kg (654 kg of FPCM). The lowest FPCM yield calculated for 1 day of standard lactation (23.9 kg) was characteristic of spring calving, whereas for complete lactations – of spring and winter calving seasons. Calving season did not have a significant influence on the content of fat and protein in milk. The level of these parameters was in a range from 4.04 to 4.10% for fat and from 3.30 to 3.31% for protein. The presented data confirm the results obtained in other studies, regarding the contents of fat and protein in milk [Sobczyńska 1989, Polański et al. 1992, Borkowska et al. 1993, Borkowska 1995, Sawa 1998]. Aforementioned studies have determined that births in winter and autumn seasons have been found to be the most favorable due to the yield of milk and its components. Nevertheless, these studies have been conducted, before the introduction of TMR feeding systems. It was observed that cows calved in the autumn and winter have two peaks of milk yield – one associated with an increase in milk yield a few weeks after birth, and the second after the introduction of green forages to feed ration in the spring [Borkowska et al. 1993].

Average daily FPCM yield calculated on the basis of test-day milkings accounted for 22.8 kg – Table 2. Similarly to the case of milk yield in complete lactation, the least favorable values for FPCM yield were reported for group of cows calved in the winter months. The highest means (23.8 and 23.4 kg) were recorded for lactations initiated in summer and autumn seasons. These values were significantly ($P \leq 0.01$) different from values calculated for the spring and winter seasons (22.2 and 22.1 kg of FPCM, respectively).

It has been determined [Borkowska and Januś 2007] that feeding cows with TMR mixtures had a positive effect on the course of lactation as compared with the traditional feeding system; i.e., the daily productivity was the highest in 2nd–3rd month after calving and then gradually decreased. The increase of milk yield in the early lactation was also observed in the present study. The rate of changes in FPCM yield depended greatly on the calving season of cows. Daily milk yield of cows calved in different seasons was similar in the first month after calving as the greatest difference (statistically insignificant) between analyzed groups accounted for 0.9 kg of FPCM. The peak of lactation milk yield was observed in the second month after calving in all the groups. Nevertheless, the rate of increase of the daily productivity was not equal. The highest rate of increase (approximately 4.1 kg of FPCM, i.e. 12.7%) was observed in case of autumn calving, whereas the smallest (approximately 0.1 kg of FPCM – 0.4%) – in the case of winter births.

In case of spring and summer calving, milk yield to 2nd month of lactation increased by 2.1 kg (by approximately 7%). The unequal rate of increase of daily milk yield caused that the differences between investigated groups were statistically significant ($P \leq 0.01$ and 0.05).

A continuous decrease in daily milk yield was stated in all examined groups from the 3rd month after calving. The daily FPCM yield decreased in 3rd month by an average of 0.7 kg of FPCM (with variation of 0.1 kg in winter season to 1.9 kg in summer season) as compared with the 2nd month. The decrease in milk yield in the course of lactation was observed for all analyzed groups. However, the comparison between 2nd and 10th month after calving revealed that the largest decrease occurred in case of autumn (14.6 kg of FPCM – 45.3%) and winter (11 kg – 40.0%) calving. The productivity in the aforementioned period related to spring and summer caving decreased by a range of 10.6 to 10.8 kg of FPCM (approximately 36%). On the basis of the presented values, it can be stated that the calving season to some extent had an influence on the shape of lactation curves. Winter births were associated with a minor increase in daily productivity followed by initially moderate, and from 5th month, rapid decline in the productivity. In the 9th and 10th month after calving, the cows calved from December to February were characterized by the lowest daily productivity (the differences statistically significant). Autumn calving was followed by a marked increase in the daily productivity at the beginning of lactation. The decrease in daily milk production in the subsequent months (excluding the 6th and 7th month after calving) accounted for approximately 6–7%. Productivity of cows in 10th month after calving for cows calved in autumn was lower (by 1.1 and 1.6 kg of FPCM – differences not significant) as compared with cows initiating lactation in the spring and summer season.

Table 1. Productivity of cows calved in different seasons
Tabela 1. Produkcyjność krów wycielonych w różnych sezonach

Calving season Sezon wycielenia	Calving Wycielenia		Length of complete lactation, days Długość pełnej laktacji, dni	Milk yield Wydajność mleka		Content in milk, % Zawartość w mleku, %		Milk yield (in kg of FPCM) per 1 day of lactation Wydajność (w kg FPCM) na 1 dzień laktacji	
	number liczba	%		kg	kg of FPCM kg FPCM	fat tłuszczu	protein białka	standard standardowej	complete pełnej
Spring – Wiosenny	281	27.7	393^{Aa}	8498	8510	4.04	3.31	23.9^{a}	22.0^{A}
Summer – Letni	280	27.6	369^{B}	8671^{a}	8702^{a}	4.04	3.30	25.5^{b}	23.6^{B}
Autumn – Jesienny	171	16.9	372^{b}	8329	8402	4.10	3.30	24.7	22.8
Winter – Zimowy	281	27.7	376^{b}	7998^{b}	8048^{b}	4.07	3.30	24.5	21.8^{A}
Total – Ogółem	1013	100.0	378	8365	8404	4.06	3.30	24.6	22.5

Means in columns marked with different letters differ significantly: capital letters – at P≤0.01; lower-case letters – at P≤0.05.
Średnie w kolumnach oznaczone różnymi literami różnią się istotnie: wielkie litery – przy P≤0,01; małe litery – przy P≤0,05.

Table 2. Daily milk yield (kg of FPCM) and its changes in the course of lactation of cows calved in different seasons (milk production in the 2nd month of lactation = 100%)

Tabela 2. Dobowa wydajność mleka (kg FPCM) i jej zmiany w przebiegu laktacji krów wycielonych w różnych sezonach (produkcja w 2. miesiącu laktacji = 100%)

Month of lactation Miesiąc laktacji	Calving season– Sezon wycielenia												Total Ogółem		
	spring – wiosenny			summer – letni			autumn – jesienny			winter – zimowy					
	n	$\bar{x}$	%	n	$\bar{x}$	%	n	$\bar{x}$	%	n	$\bar{x}$	%	n	$\bar{x}$	%
1.	276	27.2	–7.2	258	27.9	–7.0	167	28.1	–12.7	277	27.4	–0.4	978	27.6	–6.1
2.	323	**29.3**^{a}	**100.0**	309	**30.0**^{A}	**100.0**	173	**32.2**^{Ab}	**100.0**	331	**27.5**^{B}	**100.0**	1136	**29.4**	**100.0**
3.	309	28.7	–2.0	282	29.2	–2.7	168	30.3^{a}	–5.9	325	27.4^{b}	–0.4	1084	28.7	–2.4
4.	293	26.6	–9.2	255	27.6	–8.0	181	28.1	–12.7	313	26.3	–4.4	1042	27.0	–8.2
5.	278	24.2^{a}	–17.4	227	25.6	–14.7	209	26.0^{b}	–19.3	324	25.6	–6.9	1036	25.3	–13.9
6.	267	22.4^{A}	–23.5	243	25.2^{Ba}	–16.0	192	23.5^{b}	–27.0	322	23.7^{b}	–13.8	1024	23.7	–19.4
7.	235	21.7^{Aa}	–25.9	253	23.9^{B}	–20.3	194	23.5^{b}	–27.0	312	22.1	–19.6	994	22.8	–22.4
8.	204	20.3^{a}	–30.7	270	22.2^{Ab}	–26.0	190	21.5	–33.2	277	20.1^{B}	–26.9	941	21.1	–28.2
9.	232	19.1^{a}	–34.8	252	20.3^{A}	–32.3	176	19.3	–40.1	279	17.8^{Bb}	–29.5	939	19.1	–35.0
10.	206	18.7^{A}	–36.2	211	19.2^{A}	–36.0	140	17.6	–45.3	215	16.5^{B}	–40.0	772	18.0	–38.8
11th and further 11. i dalsze	768	15.0^{A}	–48.8	547	16.5^{B}	–45.0	364	14.9^{A}	–53.7	589	13.7^{C}	–50.2	2268	15.0	–49.0
Total – Ogółem	3391	22.2^{A}	–	3107	23.8^{B}	–	2154	23.4^{B}	–	3564	22.1^{A}	–	12 216	22.8	–

Means in lines marked with different letters differ significant: capital letters – at P≤0.01; lower-case letters – at P≤0.05.

Średnie w wierszach oznaczone różnymi literami różnią się istotnie: wielkie litery – przy P≤0,01; małe litery – przy P≤0,05.

Figures 1–3 illustrate the changes in subsequent lactation months in regard to the content of fat, protein and dry matter. In case of cows calved in spring and summer, the content of fat in milk decreased from 1st to 4th month and in the 4th month accounted for 3.75% in both groups. From the 5th month, the fat content generally (excluding 7th and 8th months in cows calved in spring) increased. The fat content in study of Piwczyński et al. [2001] decreased from 4.68 at calving to 4.11% in the 3rd month of lactation, and then gradually increased. The decrease in concentration of fat in milk was also observed for cows calved in autumn and winter; however, the decrease in fat content continued to the 3rd month. The concentration of this component in the 4th month of lactation was 4.01 and 3.88%, respectively, and in the following months, it generally increased; from 4.05% (in the 5th–7th month) to 4.24% (in 11th and further months) in case of cows calved in autumn and from 3.92 (in the 5th month), 4.08 (in the 9th month) to 4.50% (in 11th and further months) in case of cows calved in winter. The content of fat was higher (from reaching the lowest level until the end of lactation) in cows calved in autumn and winter as compared to those calved from March to May and from June to August.

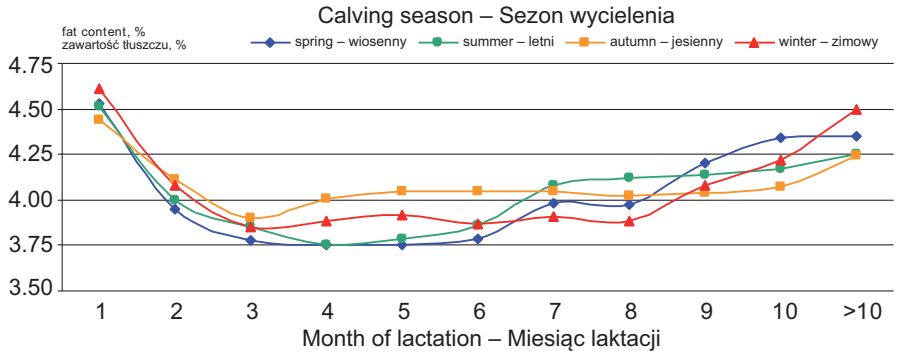

Fig. 1. Changes of fat content in milk in the course of lactation of cows calved in different seasons

Rys. 1. Zmiany zawartości tłuszczu w mleku w przebiegu laktacji krów wycielonych w różnych sezonach

The lowest content of protein in all analyzed groups, corresponding to studies of other authors [Piwczyński et al. 2001, Tomaszewski et al. 2007], was characteristic of milk obtained from cows in the 2nd month after calving. The lowest content of this component during this period was found in cows calved in spring. In case of animals calved in summer season, the protein content in 2nd month was higher by 0.4%, and for animals calved in winter – by 0.7%. The highest content of protein (3.08%) was found in milk of cows calved from September to November.

The content of protein in milk from cows calved in spring and summer was increasing in the subsequent months of lactation. In case of cows calved in winter and autumn, the changes of this component concentration were less regular. Milk from cows calved in autumn contained the highest content of protein from the 3rd to 4th month. In the 6th

month, cows calved in spring and summer outranked the other two groups. Cows calved in spring produced milk with the highest protein concentration from the 7th to 9th month, whereas in 10th and 11th and further months, milk from cows calved from December to February was found to have the highest content of protein (3.70 and 3.82%, respectively).

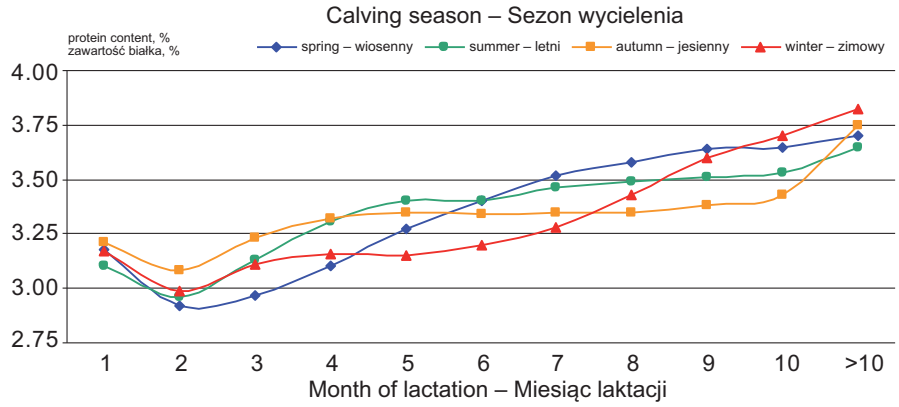

Fig. 2. Changes of protein content in milk in the course of lactation of cows calved in different seasons

Rys. 2. Zmiany zawartości białka w mleku w przebiegu laktacji krów wycielonych w różnych sezonach

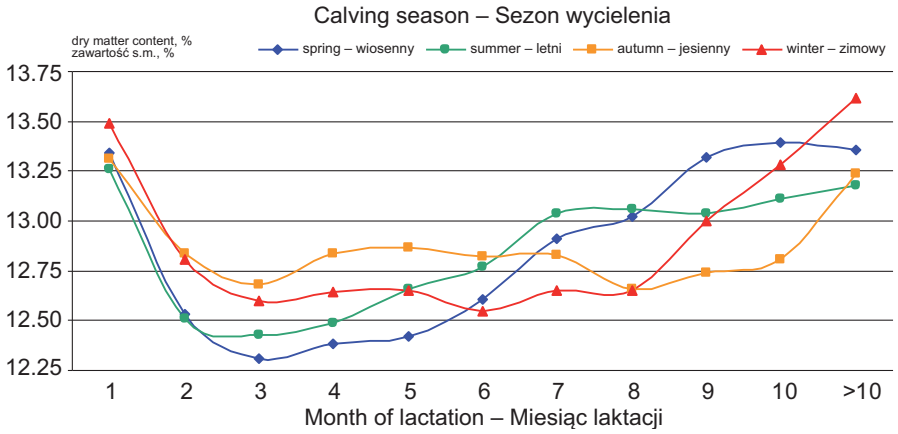

Fig. 3. Changes of dry matter content in milk in the course of lactation of cows calved in different seasons

Rys. 3. Zmiany zawartości suchej masy w mleku w przebiegu laktacji krów wycielonych w różnych sezonach

The content of dry matter milk was decreasing to the 3rd month of lactation. The lowest value (12.31%) was observed for cows that calved in spring. From the 4th month, the content of dry matter generally increased in all groups. The highest content of dry matter between

4th and 6th month of lactation was characteristic of milk from cows calved from September to November. In the 7th and 8th month, milk with the highest concentration of dry matter was produced by cows that calved in the summer months. In the final months of lactation, animals calved in spring (9th and 10th months) and winter (11th and further months) have outranked the other groups in regard to the concentration of dry matter in milk.

CONCLUSIONS

To summarize, it can be concluded that the calving season had an influence on the milk yield, its chemical composition and shape of lactation curves also in case of feeding cows with TMR system. It has been determined that calving in winter months was the least favorable due to productivity in the complete lactation. Births in this season initiated lactations characterized by the lowest daily productivity in the lactation peak as well as in the last months of lactation. The highest daily yield in early lactation, with concomitantly the most advantageous composition to 5th–6th month, was associated with autumn calving, which, however, occurred with the lowest frequency.

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WYDAJNOŚĆ KRÓW ŻYWIONYCH W SYSTEMIE TMR WYCIELONYCH W RÓŻNYCH SEZONACH

Streszczenie. Celem pracy była ocena wpływu sezonu wycielenia na wydajność i przebieg laktacji krów żywionych mieszankami pełnoporcjowymi TMR. Badania przeprowadzono w stadzie liczącym 220 krów phf cb o przeciętnej wydajności powyżej 8 tys. kg mleka. Stwierdzono, że sezon wycielenia wpływał na wydajność mleka, jego skład chemiczny i kształtowanie się krzywych laktacji. Wykazano, że najmniej korzystne ze względu na wydajność w pełnej laktacji były wycielenia w miesiącach zimowych. Porody w tym sezonie zapoczątkowywały laktacje o najniższej wydajności

dobowej w szczycie oraz w ostatnich miesiącach laktacji. Najwyższa dobowa wydajność na początku laktacji, przy jednocześnie najkorzystniejszym składzie mleka do 5.–6. miesiąca, związana była z wycieleniami jesiennymi, które jednak występowały z najmniejszą częstotliwością.

Słowa kluczowe: krowy, sezon wycielenia, TMR, wydajność i skład mleka

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