ACTA SCIENTIARUM POLONORUM

Acta Sci. Pol. Zootechnica 18(4) 2019, 39–46

www.asp.zut.edu.pl pISSN 1644-0714 eISSN 2300-6145 DOI:10.21005/asp.2019.18.4.05

ORIGINAL PAPER

Received: 28.11.2019
Accepted: 10.12.2019

COMPARISON OF FEEDING MODELS IN COWS DURING DRY PERIOD AND THEIR EFFECT ON THE INCIDENCE OF PERINATAL DISEASES AS WELL AS ON REPRODUCTIVE AND PRODUCTIVE TRAITS

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ABSTRACT

The aim of the study was to evaluate to assess different models of feeding dairy cows during the dry period and their impact on the frequency of perinatal diseases as well as reproductive and production characteristics. The research material was a herd of 67 HF black and white dairy cows with a milk yield of 10,540 kg during 305 lactations. Two cow feeding models based on TMR and PMR systems were used in the study, except that the animals in the experimental period received a feed containing calcium chloride. It was shown, that accurate balancing of feed rations during the dry period reduces the incidence of postpartum disorders. The introduction of a feed containing calcium chloride in the feed ration for cows in the close-up period reduced the occurrence of perinatal diseases, i.e. foetal membrane retention (6.4 vs 33.2%), metritis (3.9 vs 61.3%) and abomasum displacement (2.6 vs 4.4%) and clinical hypocalcemia (2.6 vs 5.9). The use of the PMR system in the close-up period with a gradual increase in the DCAD-negative compound mixture individually proved to be effective in reducing the occurrence of perinatal diseases.

Key words: dairy cows, nutrition, dry period, metabolic diseases, hypocalcaemia

INTRODUCTION

High intensification of animal production has contributed to an increase in the incidence of diseases associated with metabolic changes during periods of intensive use. This is due in part to inadequate management in dairy cow herds and the significant correlation between immune system efficiency and external factors such as diet and living conditions [Włodarczyk and Budvytis 2011, Kłos et al. 2015]. These factors can substantially limit the animals' productivity, affect the length of their productive life, and significantly influence the profitability of production [Kuczaj and Preś 2014, Kowalski 2015].

A critical period in the production cycle of dairy cows is the perinatal period, covering three weeks before calving and three weeks after calving. During this time, rapid hormonal changes associated with parturition take place, manifested by a decrease in progesterone levels and an increase in prostaglandins and oestrogens [Weich et al. 2013]. The demand for nutrients associated with the start of lactation increases rapidly, resulting in a deficit of energy, protein, minerals and vitamins, which the cow attempts to replenish from its own reserves [Martinez et al. 2012]. This causes severe disturbances of homeostasis, resulting in increased production of corticosteroids and catecholamines, which weaken the body's immune response [Goff 2008]. Proper feeding of cows throughout the dry period largely determines their performance, health and reproduction in the next lactation [McNamara et al. 2003, Łopuszańska-Rusek and Bilik 2007, Bodarski et al. 2010]. If this period is excluded from the production cycle, it is estimated that yield in the next lactation can be reduced by up to 25%. The length of this period should be at least 30–45 days before the calving date, and usually does not exceed 60 days [Kowalski 2010]. In terms of milk production, the dry period can be di-

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vided into two parts: the period in which there is no lactogenesis and the period in which colostrum production begins, which is the last three weeks before calving. According to Strzetelski et al. [2014], the diet during this period should meet the cow's requirements for life and the needs of the foetus, which grows on average 500 g · d^{-1} in the last weeks of gestation, as well as regeneration of udder glandular tissue and colostrum production. The dramatic changes in the cow's demand for nutrients during this period require proper balancing of feed rations. An additional problem in meeting nutritional needs is the decrease in dry matter intake a few weeks before calving [Contreras et al. 2004]. Studies show that in high-yielding dairy herds, 70–80% of cows have perinatal problems with subclinical hypocalcaemia, due on the one hand to the dramatic increase in the need for calcium for colostrum production, and on the other hand to mistakes in mineral nutrition during the dry period, i.e. excessive potassium, inadequate magnesium, excess calcium and inadequate phosphorus [Lean et al. 2006, Reinhardt et al. 2011]. Subclinical hypocalcemia compromised appetite, altered metabolism, and impaired function of immune cells in dairy cows [Martinez et al. 2014].

The most important complications in the perinatal period include ketosis, foetal membrane retention, hypocalcaemia, abomasum displacement, metritis and mastitis. Given that they cannot be eliminated completely, Whitaker et al. [2005] have proposed maximum acceptable rates of individual complications: ketosis 5%, foetal membrane retention 8%, abomasum displacement 3%, and hypocalcaemia 5%. If these values are not exceeded, they can be regarded as a natural consequence of the increase in milk production. At the same time, the authors noted that high yield need not be associated with a high incidence of these disorders.

The following models of cow feeding during the dry period can be distinguished:

1. Division of the dry period into the dry period proper, from 60 to 21 days before calving (far-off), when the concentration of nutrients and energy is lower, and the stage of preparation for parturition (close-up), when the concentration of nutrients and energy is increased.
2. Reduction of energy intake throughout the dry period through a restrictive diet (a specified amount of feed) or a decrease in the energy density of the feed ration.
3. A feed ration with increased concentrations of energy and nutrients throughout the dry period, lasting a shorter time (35–40 days) Kowalski 2015].
4. A small amount of concentrate feed given from the start of the dry period, with a gradual increase in its share from 14 days before calving (modified National Research Institute of Animal Production–INRA standards) during a 42-day dry period [Strzetelski et al. 2014].

The aim of the study was to assess the incidence of diseases typical of the perinatal period in relation to the manner in which cows are fed during the dry period, particularly during the last three weeks before the estimated date of parturition.

MATERIAL AND METHODS

The research material consisted of Black-and-White Polish-Friesian (PHF) dairy cows from a herd in Siedlce County. The average size of the herd is 67 cows, with a yield of 10,540 kg of milk during 305-day lactation. The cows were kept in a free-stall system, divided into two lactation groups and a separate group of dry cows, fed from a feed wagon with different rations for each group [DLG 1997, NRC 2001]. Lactating cows were fed two types of TMR, while dry cows received a TMR ration during the dry period proper (49 to 22 days before calving), and a PMR ration from three weeks before calving to delivery (basic ration plus concentrate feed twice a day, given individually). Before the changes in the feeding system for dry cows were introduced, they received one TMR ration for the entire dry period, which lasted 7 weeks on this farm. In November 2016, the feed ration for dry cows, consisting of grass silage and wheat straw supplemented with a mineral-vitamin lick, available ad libitum (control group), was changed to a basal feed ration in the period from 49 to 22 days before calving (as the only feed), which was supplemented with a special concentrate feed in the period from 21 to 0 days before calving (experimental group).

After calving, the cows remained in lactation group 2 for two weeks (TMR covering the demand for production of 25 kg of milk), and were then moved to group 1 (TMR covering the demand for production of 43 kg of milk).

We assessed the history of all cows that had calved from 5 December 2015 to 4 January 2017 (395 days), before the changes were introduced, and then from 5 January 2017 to 7 February 2018 (395 days), because at the start of January 2017 the first calves were born to cows receiving the experimental feed ration.

The evaluation of cows from just after calving to 60 days of lactation included the incidence of foetal membrane retention, metritis, abomasum displacement, and hypocalcaemia. The risk of clinical ketosis in the herd was determined by analysing the results of OWUB (Cattle Use Value Assessment) reports.

In addition, for the period from May 2017 to June 2017 (398 days, the approximate perinatal period for this herd), we analysed the average yield of the herd, average length of lactation, and fertility parameters: the length of the calving-to-conception interval (CCI), calving interval (CI), and calving-to-first-service interval (CFSI). The

Table 1. Composition of feed rations and feeds used in the perinatal period

Tabela 1. Skład dawek pokarmowych oraz mieszanek stosowanych w okresie okołoporodowym

Components Komponenty	Dry period Okres zasuszenia		Group 1 Grupa 1	Group 2 Grupa 2	Feed Mieszanka	
	before experiment, kg przed doświadczeniem, kg	proper 49–22 d before calving, kg właściwy 49–22 dni przed porodem, kg	0–14 d after calving, kg 0–14 dni po porodzie, kg	> 14 d after calving, kg > 14 dni po porodzie, kg	for close-up period, % na okres „close-up”, %	for lactating cows, % dla krów w laktacji, %
Maize silage Kiszonka z kukurydzy	–	4.30	29.00	29.00	–	–
Grass silage Kiszonka z traw	12.80	10.00	9.00	9.00	–	–
Straw Słoma	7.10	3.50	0.50	0.50	–	–
Barley grain Ziarno jęczmienia	–	1.00	–	–	47.45	41.82
Maize grain Ziarno kukurydzy	–	–	–	–	30.00	–
Fermented maize grain Kiszone ziarno kukurydzy	–	–	–	4.40	–	–
Dry sugar beet pulp Wysłodki buraczane suche	–	–	0.50	2.00	–	–
Soybean meal Poekstrakcyjna śruta sojowa	–	–	0.20	1.00	–	26.60
Rapeseed meal Poekstrakcyjna śruta rzepakowa	–	–	0.20	0.50	12.40	20.30
Molasses Melasa	–	–	0.30	0.30	–	–
Mixture for lactating cows Mieszanka dla krów w laktacji	–	–	2.50	6.60	–	–
Inert fat Tłuszcz typu inert	–	–	–	0.30	–	–
Complementary feedingstuffs for lactating cows MPU dla krów w laktacji	–	–	–	–	–	2.50
Complementary feedingstuffs for dry cows MPU dla krów zasuszonych	–	0.10	–	–	–	–
Buffer Bufor	–	–	–	–	–	2.50
Limestone Kreda pastewna	–	–	–	–	4.30	3.20
NaCl	–	–	–	–	0.25	0.75
MgO	–	–	–	–	0.70	1.58
1-Ca phosphate Fosforan 1-Ca	–	–	–	–	0.80	0.75
$CaCl_2$ 80%*	–	–	–	–	4.10	–
Total – Razem	19.90	18.90	42.20	53.60	100	100

* calcium chloride in the feed ration is much less aggressive for the oesophagus and less bitter, so it is relatively easily ingested by animals (DCAD = −13.800 mEq · kg^{-1}).
* użyty w dawce chlorek wapnia jest zdecydowanie mniej agresywny dla przełyku oraz mniej gorzki, przez co jest stosunkowo łatwo pobierany przez zwierzęta (jego DCAD = –13 800 mEq · kg^{-1}).

Table 2. Nutrient content and nutritional value of feed rations used in the perinatal period

Tabela 2. Zawartość składników pokarmowych i wartość pokarmowa dawek pokarmowych stosowanych w okresie okołoporodowym

Item	Dry period – Okres zasuszenia					Group 1 Grupa 1	Group 2 Grupa 2
	before experiment przed doświadczeniem	proper 49–22 days before calving właściwy 49–22 dni przed porodem	21–15 days before calving 21–15 dni przed porodem	14–8 days before calving 14–8 dni przed porodem	7–0 days before calving 7–0 dni przed porodem	0–14 days after calving 0–14 dni po porodzie	>14 days after calving > 14 dni po porodzie
Dry matter, kg Sucha masa, kg	11.01	9.50	11.27	12.16	12.60	18.71	27.97
NEL (MJ)	5.42	6.02	6.18	6.25	6.28	6.79	7.29
Crude protein, %* Białko ogólne, %*	10.79	11.62	11.86	11.96	12.00	13.06	15.41
BTJ, %*	6.00	6.81	7.23	7.40	7.47	8.35	9.67
Starch, %* – Skrobia, %*	–	12.23	18.20	20.53	21.57	26.90	29.70
Starch + sugar, %* Skrobia + cukry, %*	1.81	14.41	20.54	22.93	24.00	30.60	34.10
Fibre, %* – Włókno, %*	33.50	26.10	22.70	21.40	20.90	17.20	13.60
NDF, %*	64.10	52.70	46.70	44.42	43.40	41.00	32.80
ADF, %*	39.30	29.90	26.20	24.80	24.10	18.70	15.20
Ca, %*	0.33[1]	0.32	0.82	1.02	1.10	0.54	0.79
P, %*	0.23[1]	0.37	0.41	0.42	0.43	0.31	0.39
Mg, %*	0.16[1]	0.28	0.35	0.35	0.36	0.33	0.48
Na, %*	0.13[1]	0.19	0.18	0.18	0.17	0.16	0.25
K, %*	1.37[1]	1.29	1.17	1.13	1.11	1.25	1.15
Cl, %*	0.34[1]	0.49	0.81	0.94	0.99	0.40	0.40
S, %*	0.10[1]	0.10	0.12	0.12	0.13	0.13	0.17
Vitamins – Witaminy							
A, IU·day^{-1}	n.d.[1] – b.d.[1]	90000	90000	90000	90000	56250	148500
D, IU·day^{-1}	n.d.[1] – b.d.[1]	20000	20000	20000	20000	10000	26400
E, IU·day^{-1}	n.d.[1] – b.d.[1]	800	800	800	800	319	842
β–carotene, IU·day^{-1}	n.d.[1] – b.d.[1]	200	200	200	200	–	–
DCAD[2], mEq*	251.40	210.00	75.86	24.00	0.30	197.00	183.00

* per 1 kg dry matter.
* w 1 kg suchej masy.
[1] The content of macronutrients given is the natural content of these elements in the feed; the cows had access to a mineral-vitamin lick, the intake of which could not be determined.
[1] Zawartość makroelementów wynika z naturalnej zawartości tych pierwiastków w paszach, zwierzęta miały dostęp do lizawki mineralno-witaminowej, której pobrania nie dało się określić.
[2] DCAD – Dietary Cation-Anion Difference.
[2] DCAD – bilans kationowo-anionowy.

analysis was begun in May, because the average CCI for the herd is 116 days and the first cows from the experimental group calved in January.

The composition of the diets, as well as their nutrient content and nutritional value, is presented in Table 1 and Table 2. The concentrate feed used during the preparation of cows for calving (close-up) was administered twice a day, and its quantity was gradually increased according to the schedule shown in Table 3. The anionic salts (calcium chloride) used in this feed gradually reduced the DCAD (Dietary Cation-Anion Difference) during the last 21 days before calving (from +76 mEq to +0.3 mEq in the last week before parturition). In the case of delayed parturition, the feed ration was maintained at a level en-

Table 3. Schedule for administration of close-up feed during the last 21 days before calving

Tabela 3. Harmonogram podawania mieszanki „close-up" w trakcie ostatnich 21 dni przed porodem

Item Wyszczególnienie	Days before estimated calving Dni przed szacowanym wycieleniem		
	21–15	14–8	7–0
Amount of close-up feed, kg · day^{-1} Ilość mieszanki „close-up", kg · dzień$^{-1}$	2.0	3.0	3.5

Table 4. Incidence of disorders in the perinatal period

Tabela 4. Częstotliwość występowania schorzeń okresu okołoporodowego

	Calving according to the old model 5 Dec. 2015 – 4 Jan. 2017 (395 d) Wycielenia według starego modelu 05.12.2015 – 04.01.2017 (395 dni)		Calving according to the new model 4 Jan. 2017 – 6 Feb. 2018 (395 d) Wycielenia według nowego modelu 04.01.2017 – 06.02.2018 (395 dni)	
Number of observations, n Liczba obserwacji, n	68		76	
	Number of cases Liczba przypadków	%	Number of cases Liczba przypadków	%
Foetal membrane retention Zatrzymanie błon płodowych	26	38.2	5	6.4
Metritis	41	61.3	3	3.9
Abomasum displacement Przemieszczenie trawieńca	3	4.4	2	2.6
Hypocalcaemia Zaleganie poporodowe	4	5.9	2	2.6
Subclinical ketosis Podkliniczna ketoza	0	0	1	1.3

suring DCAD + 0.3 mEq (3.5 kg diet · d^{-1}). Analysis of the urine pH of cows during the last week before calving indicated values between 7.1 and 7.8.

RESULTS

The incidence of diseases typical of the perinatal period is presented in Table 4. The introduction of the basal feed ration gradually enriched with a negative-DCAD feed, compared to the previously used TMR and uncontrolled access to a mineral-vitamin lick, significantly reduced cases of foetal membrane retention and metritis, and to a much lesser extent hypocalcaemia and abomasum displacement. Based on OWUB reports, one case of elevated milk BHBA and acetone content was found in the experimental group, which may indicate subclinical ketosis.

OWUB analysis showed an increase in milk yield of 310 kg in lactation. The average yearly length of lactation in the period analysed decreased by 18 days (Table 5). Analysis of fertility traits showed that the average CCI in the experimental group was 8 days longer than in the control group (117 vs 125), the average calving interval increased by 4 days (397 vs 401), and the calving-to-first-service interval decreased from 115 to 108 days, which may indicate an improvement in the condition of the reproductive system after parturition and earlier readiness for reproduction.

DISCUSSION

The energy level in the experimental group during the dry period proper was in accordance with recommendations for energy intake for dry cows (intermediate energy level) [Huang et al. 2014]. Although the increase in the proportion of the close-up feed in the ration meant that energy intake exceeded the energy requirements of cows a week before calving, no negative effects on the cows' health or reproduction were noted.

Analysis of the energy density of the feed rations indicates that, according to current reports [Martinez et al. 2014], the control diet is more suitable than the experimental diet, as there is no risk of excessive energy intake. However, its use did not yield the intended results. In addition, cows beginning lactation had to adapt to a very aggressive change to a high-starch diet, which could cause digestive disorders, including abomasum displace-

Table 5. Analysis of the lactation yield and fertility traits of the herd (402 days of observation)

Tabela 5. Analiza wydajności laktacyjnej oraz cech płodności stada (402 dni obserwacji)

Cecha Trait	Start of observations, May 2017 Początek obserwacji, maj 2017	End of observations, June 2018 Koniec obserwacji, czerwiec 2018
Mean lactation yield of herd, kg milk/305 days Średnia wydajność laktacji stada, kg mleka/305dni	10230	10540
Mean length of lactation – yearly mean, days Średnia długość laktacji – średnia roczna, dni	179	161
Mean calving-to-conception interval, days Średni okres międzyciążowy, dni	117	125
Mean calving interval, days Średni okres międzywycieleniowy, dni	397	401
Mean calving-to-first-service interval, days Średni okres przestoju poporodowego, dni	115	108

ment. A fundamental mistake in the use of this feeding system seems to be the uncontrolled intake of minerals and vitamins (from the lick). Due to individual taste preferences, the cows could ingest too much or too little of the vitamin and mineral mix, and thus the intake was not equal to the demand. In the case of dry cows, which consume about half as much dry matter as lactating cows, precise intake of minerals and vitamins seems to be particularly important for their health and subsequent productivity. The use of a mineral and vitamin supplement throughout the dry period (experimental group) enabled a uniform supply of minerals and vitamins, in contrast with the mineral and vitamin lick, whose uptake is impossible to determine. Low-energy rations with a large amount of roughage contain more potassium than rations with some starch content. DCAD was highest in the control group among all diets used during the observations. It is highly likely that the high rate of placental retention and metritis in this group was due to mineral vitamin deficiencies and subclinical hypocalcaemia caused by metabolic alkalosis, rather than other causes.

During veterinary inspection, better reproductive system activity after parturition was observed in the experimental group, which may indicate a reduction in the negative energy balance during the perinatal period. This was very likely the result of improved appetite after calving and improved immune status, possibly due to feeding with a complete ration close to their requirements.

Regarding the feeding models for the dry period described by Strzetelski et al. [2014], the control diet is similar to model 2, while the experimental diet is very similar to model 4. Either model can be introduced on medium-sized and small farms. Difficulties are usually associated with introducing a new ration in the daily work schedule. In addition, feed wagons on farms are often too large for the stocking density. This makes it difficult or even impossible to prepare a homogeneous feed for a small group of animals such as dry cows. Another problem is ensuring that straw, which is the main component of diets for dry cows, is adequately chopped. One solution may be to use a lactation TMR, mix it with straw, and balance the minerals in accordance with the needs of dry cows. In herds without a feed wagon, the only solution is to feed the roughage in the right proportions separately, and to regulate DCAD with specially prepared feed given individually. According to the NAHMS [2007] survey, 26.7% of producers supplement anions to decrease the DCAD of the prepartum diet to aid against hypocalcemia (< 8 mg · dL^{-1} total blood Ca) [DeGaris and Lean 2008].

The urine pH of cows in the experimental group before calving was close to neutral or slightly alkaline. Therefore, with a DCAD of 0.3 mEq, the values recommended by Strzetelski et al. [2014] could not be achieved. Nevertheless, the incidence of foetal membrane retention and metritis decreased significantly. This may indicate that neutral DCAD diets introduced shortly before calving are sufficient to reduce most postpartum complications.

Analysis of roughage, taking into account the content of macronutrients, is particularly important in feeding dry cows [Kuczaj et al. 2009]. Variation in the content of elements in feed depends mainly on the phase of harvest, species and fertilization. Plants intensively fertilized with solid and liquid cattle manure have particularly high content of potassium and phosphorus, and thus the proportion of this type of feed for dry cows should be limited. The high incidence of illness in cows in the perinatal period may be due to the lack of efforts by cattle farmers and nutrition advisers to develop a model adjusted for the herd and the low level of awareness of the importance of cow nutrition during the dry period.

CONCLUSIONS

The perinatal period is the most difficult period for the cow in the entire production cycle. Accurate balancing of

feed rations during the dry period reduces the incidence of postpartum disorders. The introduction of a feed containing calcium chloride in the feed ration of Holstein-Friesian cows in the close-up period reduced the incidence of perinatal diseases, i.e. foetal membrane retention (6.4 vs 33.2%), metritis (3.9 vs 61.3%), abomasum displacement (2.6 vs 4.4%)) and hypocalcemia (2.6 vs 5.9%). To sum up, the use of the PMR system in the close-up period with a gradual increase in the DCAD-negative compound mix individually proved to be effective in reducing the occurrence of perinatal diseases.

ACKNOWLEDGEMENT

This study was financed by the funds of the Ministry of Science and Higher Education of Poland (statutory research fund of the Siedlce University of Natural Sciences and Humanities No 373/14/S).

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PORÓWNANIE MODELI ŻYWIENIA KRÓW W OKRESIE ZASUSZENIA I ICH WPŁYW NA CZĘSTOTLIWOŚĆ WYSTĘPOWANIA SCHORZEŃ OKOŁOPORODOWYCH ORAZ CECHY REPRODUKCYJNE I PRODUKCYJNE

STRESZCZENIE

Celem badań była ocena różnych modeli żywienia krów mlecznych w okresie zasuszenia i ich wpływu na częstotliwość występowania schorzeń okołoporodowych oraz cechy reprodukcyjne i produkcyjne. Materiał badawczy stanowiło stado 67 krów mlecznych rasy HF odmiany czarno-białej o wydajności mleka 10 540 kg w ciągu 305 laktacji. W badaniach zastosowano dwa modele żywienia krów oparte na systemach TMR i PMR, z tym że zwierzęta w okresie doświadczalnym otrzymywały mieszankę paszową zawierającą chlorek wapnia. Wykazano, że dokładne zbilansowanie dawek w okresie zasuszenia znacząco ogranicza występowanie zaburzeń poporodowych. Wprowadzenie mieszanki paszowej zawierającej chlorek wapnia do dawki pokarmowej dla krów w okresie „close-up" ograniczyło występowanie schorzeń okołoporodowych, tj.: zatrzymanie błon płodowych (6,4 vs 33,2%), metritis (3,9 vs 61,3%) przemieszczenie trawieńca (2,6 vs 4,4%) i hypocalcemię (2,6 vs 5,9%). Zastosowanie systemu PMR w okresie „close-up" ze stopniowym zwiększaniem mieszanki o ujemnym DCAD zadawanej indywidualnie okazało się skuteczne w ograniczeniu występowania schorzeń okresu okołoporodowego.

Słowa kluczowe: krowy mleczne, żywienie, okres zasuszenia, choroby metaboliczne, hipokalcemia

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