

The efficiency of dairy cattle nutrition on chosen farms of central-eastern Poland

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Abstract: *The efficiency of dairy cattle nutrition on chosen farms of central-eastern Poland.* Practical nutrition of dairy cows should take into account the physiology of digestion in ruminants and the genetic potential of these animals. A fundamental role in their appropriate nutrition is played by detailed assessment of the nutritive value of applied diets. The aim of the study was to analyse the effectiveness of feeding dairy cows with feed doses balanced in accordance with the INRA system in different periods of lactation and to evaluate the nutritive value of the diets as well as the milk yield and composition. The research was carried out on eight farms rearing on average 55 black-and-white Holstein-Friesian dairy cows. The cows in the study farms were fed in accordance with the PMR system. Mixed rations administered twice a day from the mixer wagon were the basic diet for the milk cows. Cows yielding more than 20 litres of milk received complementary feedstuffs from a feeding station. The investigations demonstrated an adequate and characteristic chemical composition and nutritive value of the feedstuffs. The efficiency of milk production and the composition of the milk produced by the farmed cows did not differ significantly from the average values typical of the black-and-white variety

of the Polish Holstein-Friesian breed. The results confirmed the advisability of balancing food rations based on modern feed evaluation systems.

Key words: nutrition, dairy cows, efficiency of milk production, milk chemical composition

INTRODUCTION

Practical nutrition of dairy cows should take into account the physiology of digestion in ruminants and the genetic potential of these animals. This facilitates adequate identification of nutritional requirements and, consequently, optimal balancing of feed rations (Vandehaar et al. 2016). Errors in cattle nutrition result not only in reduced productivity but also in health disorders. Solution of the nutritional, metabolic, or deficiency-related problems affecting the function of many organs can improve the general health status of the herd and reduce the incidence of animals' disease on the farm

(Van and Sniffen 2014, Klebaniuk et al. 2016, Klebaniuk et al. 2017).

A fundamental role in appropriate animal nutrition is played by thorough assessment of the nutritive value of applied diets. Underestimation of their value prevents optimal coverage of nutritional needs. This may result in a low level of production despite the high genetic potential, especially in dairy cows. The current methods for assessment of the feed value take into account the digestibility of protein and energy both inside and outside the rumen. Consideration of the protein and energy balance provides more detailed and accurate coverage of cows' nutritional requirements (Daniel et al. 2017, Klebaniuk et al. 2018).

The aim of the study was to analyse the effectiveness of feeding dairy cows with diets balanced in accordance with the INRA recommendation (Strzetelski et al. 2014) in different periods of lactation and to evaluate the nutritive value of the diets as well as the milk yield and composition.

MATERIAL AND METHODS

The investigations were carried out between September 2017 and January 2018 on eight farms located in Lubelskie and Podlaskie Provinces. The black-and-white Polish Holstein-Friesian cows and young stock reared for rejuvenation of the herd were kept on the farms. The same system of nutrition and feed administration and the cattle maintenance system (free-stall with division into production groups) were applied on the analysed farms. During the research period, the average number of animals per herd was 110, including 55 dairy cows. The

average area of the farms was 65 ha, with 20 ha of silage maize cultivation, 25 ha of grassland, and 20 ha covered by cereal cultivation.

Every two weeks during the study, the balance in the feed rations applied was evaluated and corrected with reference to the productivity of the cows, and samples were collected for chemical analyses. The contents of basic nutrients, i.e. dry matter (d.m.), crude protein, crude fibre, ether extract, and crude ash in the roughage-concentrate mixtures were analysed according to the AOAC (2012) standards. The nutritive value of the feed ration components was calculated on the basis of their chemical composition using programme Winwar ver. 2.1.3.13.

The assessment of the milk yield and composition was carried out for over five months based on reports on monthly cow milking trials conducted by the Polish Federation of Cattle Breeders and Milk Producers. In each herd, four production groups of cows were distinguished with reference to the lactation days (early lactation – up to day 40 after calving, from lactation day 41 to 100, from lactation day 101 to 200, and after lactation day 200) in accordance with the milk yield report as well as a group of dry cows.

The results of the chemical composition and nutritive value of feed as well as data on the milk yield and composition were subjected to basic statistical analysis, and means and standard deviations (SD) were calculated. One-way analysis of variance with Duncan's test ($\alpha = 95$; $P < 0.05$) was applied to the results of the nutritive value of the feedstuffs sampled on each farm. There were no statistically significant differences between the values of the determined parameters

between the farms; hence, the paper presents means from the entire experiment (from eight farms). The results were analysed statistically with the use of Statistica 10.0 software (StatSoft Inc. 2011).

RESULTS AND DISCUSSION

The cows on the analysed farms were fed following the PMR (Partial Mixed Ration) system.

Mixed rations administered twice a day from the mixer wagon were the basic diet for the milk cows (Table 1). Additionally, cows yielding more than 20 litres of milk received complementary feedstuffs from a feeding station. The 'Bestermine Somi' mineral feed blend, 'Rumen Activ' buffering agent concentrate, baking soda, and chalk fodder were used as feed additives in accordance with the manufacturer's recommendations and animals' needs

Additionally, the cows had unlimited access to a salt lick composed of NaCl 97%, Cu 1200 mg/kg, and Co 100 mg/kg.

TABLE 1. Average composition of the basic diet

Type of feed	Amount (%)
Wheat straw	1.0
Haylage	28.3
Maize silage	40.5
Beet pulp silage	20.3
Cereal meal*	4.5
Protein concentrate 40%	2.0
Post-extraction rapeseed meal	3.0
Feed additives	0.4

*average composition: wheat 50%, barley 35%, triticale 5%, maize 10%

In the first lactation period, the cows also received a commercial "starter diet" from a feeding station (post-extraction soybean meal, wheat, protected fat, 'Rumen Activ' buffering agents). Additionally, cows yielding over 20 litres per day throughout the lactation period were administered complementary feedstuffs (Table 2) as recommended (Strzetelski et al. 2014).

The protein concentrate and post-extraction soybean meal were the main sources of protein in the roughage, as they provided 315.9 and 252.4 PDIN as well as 215.7 and 147.0 PDIE, respectively, in 1 kg d.m. of the blend. The "starter" diet, complementary feedstuffs, and cereal meal administered as energetic fodder provided on average 1.05 UFL and met the recommended proportions of the energy-protein ratio optimally for the production groups of the dairy cows (Table 2). The highest values of filling parameters among the roughages were determined for wheat straw (1.6 LFU/1 kg d.m.), whereas the other roughages provided on average 1.06 LFU/1 kg d.m. (Table 3). The chemical composition and nutritive value of the feeds were characteristic for this type of feedstuffs and similar to these parameters reported in the literature (Strzetelski et al. 2014, Lamminen et al. 2017).

The data on the nutritional value per 1 kg d.w. of PMR (Table 3) indicate that the feed ration for the cows met their average requirement at production of 20 litres of milk. In comparison with literature reports (Strzetelski et al. 2014), the ration was shown to contain a slight excess of PDI protein. The mean feed dose per milk cow (body weight: 680 kg, milk yield: 20 litres, fat and protein con-

TABLE 2. Average chemical composition of applied feedstuffs

Parameters	Feedstuff				
	Post-extraction rapeseed meal	“Starter” mixture	Cereal meal	Complementary feedstuffs	Protein concentrate
Dry matter (%)	87.97	88.22	85.87	87.74	87.89
<i>SD</i>	±0.24	±0.48	±1.26	±0.98	±0.48
Per 1 kg dry matter (g)					
Crude ash	76.5	105.4	20.7	88.0	77.0
<i>SD</i>	±0.15	±0.21	±0.34	±0.54	±0.96
Crude protein	442.8	268.0	148.8	251.3	504.5
<i>SD</i>	±1.24	±0.48	±1.26	±0.94	±0.31
Crude fat	27.7	52.5	16.2	35.1	19.2
<i>SD</i>	±0.57	±0.74	±0.32	±0.94	±0.31
Crude fibre	134.1	86.2	37.3	92.7	104.9
<i>SD</i>	±0.49	±0.32	±0.15	±0.47	±0.84
NFE	318.9	487.9	777.0	532.9	294.3
<i>SD</i>	±0.32	±0.61	±0.32	±0.24	±0.35
Nutritive value per 1 kg dry weight					
UFL	0.96	1.05	1.06	1.03	1.05
PDIN (g)	252.4	159.7	86.3	150.8	315.9
PDIE (g)	147.0	112.1	93.8	115.6	215.7
LFU	–	–	–	–	–

SD – standard deviation; NFE – nitrogen-free extract; UFL – Feed Unit for milk production; PDIN – protein truly digestible in the small intestine when N limits microbial protein synthesis; PDIE – protein truly digestible in the small intestine when energy limits microbial protein synthesis; LFU – fill units for cows

tent in the milk: 4.45 and 3.50%, respectively) exceeded the demand for PDIE in 4.5% and for PDIN in 6.3% at 0.5% energy excess.

Balancing the feed ration, especially in terms of energy and protein supply, is a prerequisite for the normal course of metabolic processes and the efficiency of milk production consistent with the cow's milk yield potential accompanied by an appropriate composition of milk (Matras et al. 2000, Sobotka et al. 2014). In order to reduce the PDI protein excess in the cows' feed ration, it

is advisable to limit the proportion of feeds providing this type of protein, mainly post-extraction rapeseed meal. However, it can be assumed that, with such inconsiderable differences between the demand and supply meeting the feed requirements, the average daily feed intake in the ration as well as the energy and protein demand in cows with specific milk production levels, estimated according to the standards (Strzetelski et al. 2014), in the respective nutrition periods revealed optimum balance of the feed rations.

TABLE 3. Average chemical composition of the roughages included in PMR and the whole PMR on the experimental farms

Parameters	Wheat straw	Beet pulp silage	Haylage	Maize silage	PMR
Dry matter (%)	89.17	23.18	55.31	36.39	46.34
<i>SD</i>	±0.24	±0.37	±1.08	±0.98	±0.64
Per 1 kg dry matter (g)					
Crude ash	42.0	77.8	68.0	106.0	87.6
<i>SD</i>	±0.54	±0.31	±0.54	±0.38	±0.91
Crude protein	34.6	104.3	180.9	89.8	147.6
<i>SD</i>	±0.64	±0.75	±0.31	±0.42	±0.84
Crude fat	15.9	4.9	38.4	38.7	24.3
<i>SD</i>	±0.95	±0.09	±0.21	±0.19	±0.13
Crude fibre	429.8	194.2	213.4	181.8	275.6
<i>SD</i>	±0.97	±0.23	±0.64	±0.84	±0.32
NFE	477.7	618.8	499.2	583.7	464.9
<i>SD</i>	±0.26	±0.38	±0.51	±0.84	±0.62
Nutritive value per 1 kg dry weight					
UFL	0.40	0.98	0.92	0.81	0.80
PDIN (g)	20.1	67.6	103.5	53.1	87.2
PDIE (g)	41.9	84.6	88.6	70.0	85.5
LFU	1.60	1.05	1.10	1.03	0.97

SD – standard deviation; PMR (Partial Mixed Ration); NFE – nitrogen-free extract; UFL – Feed Unit for milk production; PDIN – protein truly digestible in the small intestine when N limits microbial protein synthesis; PDIE – protein truly digestible in the small intestine when energy limits microbial protein synthesis; LFU – fill units for cows

Milk brought to collecting centres should contain on average 3.2% of protein, 3.8% of fat. The milk from the analysed farms was characterised by a good chemical composition meeting the purchase requirements (Table 4). The present investigations have confirmed the possibility of maintenance of

TABLE 4. Milk yields and composition

Lactation, days	Cows	Yield (kg)		Fat (%)		Protein (%)	
		mean	<i>SD</i>	mean	<i>SD</i>	mean	<i>SD</i>
1–40	7	32.1	±0.21	4.32	±0.09	3.31	±0.06
41–100	8	32.2	±0.18	4.10	±0.05	3.28	±0.04
101–200	14	26.6	±0.15	4.59	±0.07	3.56	±0.12
Over 200	16	24.2	±0.09	4.57	±0.06	3.86	±0.08
Mean	45	27.5	±0.13	4.45	±0.05	3.50	±0.07

SD – standard deviation

high milk yields in dairy cows receiving optimal nutrition, which were higher (Table 4) than the average value (23–25 kg) reported in the literature (Sobotka et al. 2011). The protein content in milk is largely dependent on genetic determinants, whereas the fat content can be modified with adequate nutrition. The amount of fat in milk depends on the ratio of roughage to concentrate mixtures in the feed ration. Additionally, the physical structure of roughage as well as the concentration and composition of structural carbohydrates (crude fibre, ADF, and NDF) contribute to an increase in the fat content in milk (Bałowski et al. 2013, Stoffel et al. 2015). The average fat content in the milk produced on the analysed farms was approximately 4.3%. The chemical composition of the milk collected from the experimental cows varied depending on the lactation period, and the best nutritive values were determined for the milk produced by cows lactating for over 200 days. Similar results were obtained by van Knegsel et al. (2014), who investigated Holstein-Friesian dairy cows as well. To improve the chemical composition of milk from early lactation, they shortened or even omitted the drying period, which shifted the milk yield from the postpartum to the prepartum period and improved the energy balance in the early lactation period.

SUMMARY

The present study demonstrated an adequate and characteristic chemical composition and the nutritive value of the feedstuffs. The efficiency of milk production and the composition of the milk yielded by the cows on the analysed

farms did not differ substantially from the average values typical of the black-and-white variety of the Polish Holstein-Friesian breed. The results confirmed the advisability of balancing food rations based on the modern INRA feed evaluation system.

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Streszczenie: *Efektywność żywienia krów mlecznych w wybranych gospodarstwach środkowo-wschodniej Polski.* Praktyczne żywienie krów mlecznych powinno uwzględniać fizjologię trawienia u przeżuwaczy oraz potencjał genetyczny zwierząt, a podstawową rolę w prawidłowym żywieniu tych zwierząt odgrywa szczegółowa ocena wartości pokarmowej skarmianych pasz. Za cel pracy przyjęto analizę efektywności żywienia krów mlecznych w różnych okresach laktacji, przy bilansowaniu dawek pokarmowych według systemu INRA, oceniając wartość pokarmową skarmianych pasz w dawkach oraz wydajność i skład mleka. Badania przeprowadzono w ośmiu gospodarstwach utrzymujących krowy rasy holsztyńsko-fryzyjskiej odmiany czarno-białej, średnio 55 krów mlecznych. Krowy w gospodarstwach objętych badaniami żywione były w systemie PMR. Podstawową dawkę pokarmową dla krów dojnych stanowiły wymieszane pasze zadawane dwa razy dziennie z wozu paszowego, a dodatkowo krowy o wydajności powyżej 20 litrów mleka otrzymywały mieszankę treściwą uzupełniającą ze stacji paszowej. W przeprowadzonych badaniach stwierdzono, że skład chemiczny oraz wartość pokarmowa pasz były prawidłowe i charakterystyczne dla ich rodzaju. Wydajność krów i skład mleka krów w analizowanych gospodarstwach nie odbiegały zasadniczo od wartości średnich dla krów rasy polskiej holsztyńsko-fryzyjskiej, odmiany czarno-białej. Wyniki potwierdziły zasadność bilansowania dawek pokarmowych na podstawie współczesnych systemów wartościowania pasz.

Słowa kluczowe: żywienie, krowy mleczne, wydajność, skład mleka

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