

COMPOSITION OF MILK AND BLOOD METABOLITES IN HIGH PRODUCTIVITY DAIRY COWS ON PASTURE

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Summary. The study has involved a comparison of yield performance of Holstein-Friesian cows (n=38) fed conserved feeds (grass silage, maize silage, ensiled beet pulp) with their analogues grazing on pasture. Pasture grazing increased the milk yield performance of cows compared to the diet of conserved feeds, which increased level of urea in the milk. The basic chemical composition of milk did not varied significantly between different feeding systems. However, daily fat level in milk slightly increased when cows were on green pasture fodder.

Keywords: dairy cows, feeding systems, performance, blood metabolites.

AUKŠTO PRODUKTYVUMO PIENINIŲ KARVIŲ PIENO IR KRAUJO METABOLITŲ SUDĖTIS GANYKLINIŲ LAIKOTARPIU

Santrauka. Moksliniais tyrimais palygintas Holšteino ir Fryzų veislės karvių (n=38), šeriamų konservuotais pašarais (žolės, kukurūzų ir runkelių minkštimo silosu), primilžis su tos pačios veislės ganyklose ganomų karvių primilžiu. Pastebėta, kad ganyklose ganomų karvių primilžis yra didesnis palyginti su konservuotais pašarais šeriamų karvių. Šis padidėjimas koreliuoja su padidėjusiu urėjos kiekiu piene. Nepastebėta didelių pagrindinių pieno cheminių sudėties komponentų skirtumų tarp abiejų šėrimo tipų. Stebima tendencija, kad kasdieninis riebalų kiekis bei primilžis padidėja, jei karvės ganosi ganyklose.

Raktažodžiai: pieninės karvės, šėrimo tipai, primilžis, kraujo metabolitai.

Introduction. Despite the undeniable progress in the production of feeds and nutrition of cows, the traditional feeding system on pasture as a primary source of nutrients is still in widespread use, mainly because of the effect grazing has on health of cows and production of healthy milk. Pasture is also considered to be the least expensive source of nutrients (Succi and Crovetto 1996; Müller and Fales 1998; Nardone and Valfre 1999; Boland and Mac Gibbon 2001; Whittemore 2001). Nevertheless, availability of high quality conserved feeds promotes new feeding systems. Such breeds as Holstein-Friesian cows, which have a high demand for nutrients, frequently require to be fed conserved feeds, the nutritive value of which is constant throughout a whole year.

The aim of the present study has been to compare the performance of Holstein-Friesian cows receiving conserved feeds versus those grazing at pasture.

Material and methods. The study was carried out on 76 Holstein-Friesian cows divided into two groups. Selection of animals for the experiments was done mainly according to the number of days they had been milked and the milk yield at the beginning of lactation. The experiments covered the period when cows were fed conventionally in the stall and when they grazed on pasture. The basic feeding ration contained maize silage (10 kg), grass silage (15 kg), pressed beet pulp silage (10 kg) and fodder mix (4.5 kg). While being at pasture, the cows received additional 10 kg of maize silage and 4.5 kg fodder mix. In both periods of the study, concentrate was used as a production feed for cows yielding over 20 kg of milk (conventional stall) and 25 kg of milk (pasture). The amount of the lactation concentrate per cow was 0.45

kg/kg of milk yield (1 kg of the concentrate contained 0.9 UFL, 170 g crude protein, 117 g PDIN, 104 PDIE, 7 g Ca and 5 g P).

The following were determined in all the fodders: content of the basic nutrients by standard methods (AOAC,1990), neutral detergent fibre (NDF) and acid detergent fibre (ADF) by Goering and Van Soest's method (1970) using a Tecator (Fibertec M), calcium by Flapho 4 (Carl Zeiss Jena), phosphorus by Fiske Subbarow's standard method. The nutritive value of feeds was expressed in INRA-1988 units calculated from the nutrient content, using WINWAR computer software. The chemical composition and nutritive value can be found in table 1.

Milk yield was recorded every 30 days and weighted samples from the morning and evening milking were analysed for determination of milk composition. The milk samples collected individually from each cow were analysed in COMBIFOSS to determine the concentration of fat, protein, urea and somatic cell count.

Blood samples were taken from the jugular vein prior to the morning feeding. Serum was separated by centrifugation at 2000 x g for 15 min. and stored at -20 C. Serum samples were analysed for glucose, triglycerides, total cholesterol and BUN level as well as for alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities using the tests of Alpha Diagnostics Methods (Catalogue no. G-6518-400; T-6531-400; C-6509-400; B-6550-200; G-6519-400; T-6528-500). The results of the experiments were analysed statistically with one-factor analysis of variance and Duncan's tests.

Results. The results (table 1) suggest that the total

protein content in the dry matter of grass silage was lower than in green fodder from pasture grass. Differences were also found in the content of crude fibre, ADF and NDF, which were reflected by a lower energy value and PDI content in grass silage versus pasture green fodder.

The composition of the basic feeding rations is specified in table 2. The mean dry matter uptake was 15.5 kg in group 1, and 18.5 kg in group 2. Net energy, crude fibre, NDF and ADF as well as Ca and P concentrations per 1 kg DM were similar in all the rations. The average

daily milk yield (table 3) of cows grazing at pasture was higher than that of cows receiving conserved feeds (group 1), regardless of the time of lactation. In the first (to day 100) and second (101-200 days) period of lactation, the average daily FCM yield in group 2 was higher by 18 and 15%, respectively, compared with group 1. The most evident influence of pasture grazing on milk yield was observed after 200 days of milking. The FCM yield of these cows compared to group 1 was 36% higher (22.7 vs 16.7 kg).

Table 1. Chemical composition and nutritive value of feeds

Item	Maize silage	Grass silage	Ensiled beet pulp	Pasture grass	Concentrate
Dry matter, %	32.40	45.80	15.80	18.79	88.42
Nutrients, g·kg ⁻¹ DM					
Organic matter	967.0	840.4	905.1	914.3	939.2
Crude protein	79.9	108.9	106.3	154.9	191.3
Ether extract	42.3	29.0	2.5	27.7	15.0
Crude fibre	189.8	325.0	167.1	265.0	32.6
N-free extractives	655.0	377.5	629.2	466.7	700.3
Ash	33.0	159.6	94.9	85.7	60.8
NDF	357.4	480.1		392.6	61.9
ADF	200.7	335.4		273.0	38.1
Ca	2.84	8.01	12.47	8.40	6.89
P	2.80	5.74	1.71	3.64	5.89
Nutritive value of feed/ kg of DM					
UFL	0.90	0.79	1.01	0.87	1.13
PDIN (g)	49.1	76.4	60.0	97.2	120.0
PDIE (g)	62.9	63.5	84.0	89.6	125.1

Table 2. Composition and nutritive value of the feeding rations

Specification	Group 1 – (conventional)	Group 2 – (pasture)
Composition (% DM)	20.4	17.5
Maize silage	44.4	—
Grass silage	10.0	—
Ensiled beet pulp	—	61.0
Pasture green fodder Concentrate	25.2	21.5
Concentration, (kg⁻¹DM)		
UFL	0.92	0.92
Total protein (g)	129.9	152.0
PDIN (g)	87.3	94.8
PDIE (g)	81.5	90.9
Crude fibre (g)	200.9	201.7
NDF (g)	310.9	315.2
ADF (g)	199.1	220.0
Ca (g)	7.08	7.07
P (g)	5.02	5.87

The concentration of fat in milk depended on the time of lactation rather than the feeding method (table 3). The highest fat concentration was found in the milk produced by cows from either group in the third period of lactation. The concentration of fat in the milk of cows until day 100 of lactation was slightly higher (by 0.13%) in group 2 when fed on pasture. The lowest concentration of fat in milk from both groups of cows was found between 101

and 200 days of milking. The two different methods of feeding the cows had no effect on the percentage of protein in milk during the lactation period analysed (table 3). The average protein level in milk between 101 and 200 days of milking was 3.40%, rising afterwards to 3.71% in both groups of cows. On the other hand, in the early lactation (until day 100), milk of the cows grazing on pasture contained more protein (by 0.15%).

Table 3. Average daily milk yield and protein and fat concentration in milk

Item		Days of lactation							
		<100		101-200		>200		Total	
		Group							
		1	2	1	2	1	2	1	2
Milk kg d ⁻¹	\bar{x}	31.7	36.5	23.0	25.6	16.2	21.9	23.4 ^a	27.3 ^b
	s	6.42	8.54	3.84	3.88	3.91	6.27	7.00	7.79
FCM kg d ⁻¹	\bar{x}	31.1	36.7	21.6	24.8	16.7	22.7	22.9 ^a	26.9 ^b
	s	6.83	7.83	4.51	4.02	4.18	6.25	7.08	7.70
Fat %	\bar{x}	3.90	4.03	3.67	3.77	4.21	4.11	3.86	3.91
	s	0.80	0.35	0.49	0.41	0.25	0.37	0.57	0.41
Fat g d ⁻¹	\bar{x}	1236	1471	844	965	682	900	899.3 ^a	1062.8 ^b
	s	223	199	111	163	176	253	201	309
Protein %	\bar{x}	3.02	3.17	3.40	3.40	3.71	3.72	3.38	3.42
	s	0.32	0.38	0.21	0.24	0.15	0.26	0.33	0.34
Protein g d ⁻¹	\bar{x}	957	1157	782	870	601	815	764.5 ^A	926.3 ^B
	s	207	209	109	129	125	225	202	242
Urea mg/l	\bar{x}	182.7 ^a	259.8 ^b	248.7	289.1	197.7	236	226.5 ^a	269.8 ^b
	s	55.8	54.9	51.1	73.4	52.2	40.5	56.2	83.2
SCC x10 ³	\bar{x}	88	53	68	117	103	121	99.2	92.4
FCM/DM kg kg ⁻¹	\bar{x}	1.55	1.63	1.27	1.34	1.05	1.23	1.29	1.40

a, b = P ≤ 0.05

A, B = P ≤ 0.01

Table 4. Some metabolic indices in blood serum of dairy cows

Item		Days of lactation					
		< 100		101-200		>200	
		Group					
		1	2	1	2	1	2
Glucose mmol/l	\bar{x}	3.16	3.32	3.49	3.64	3.65	3.72
	s	0.61	0.84	0.42	0.63	0.50	0.62
Triglycerides mmol/l	\bar{x}	0.061	0.057	0.076	0.080	0.101	0.112
	s	0.009	0.010	0.014	0.011	0.019	0.021
Total cholesterol mmol/l	\bar{x}	4.54	4.97	5.56	6.36	5.23	5.92
	s	0.55	0.60	0.78	0.82	0.60	0.90
BUN mg/dl	\bar{x}	11.02 ^a	15.02 ^b	13.65	16.20	11.65	13.89
	s	2.5	3.4	5.2	4.4	3.4	2.4
MUN mg/dl	\bar{x}	8.54 ^a	12.14 ^b	11.62	13.51	9.24	11.03
	s	2.6	5.8	2.4	3.4	2.4	1.9
MUN/BUN %	\bar{x}	77.5	80.8	85.1	83.4	79.3	79.4
AST U/L	\bar{x}	61.4	71.7	51.7	60.7	54.1	61.3
	s	6.2	5.0	5.3	8.0	7.0	9.0
ALT U/L	\bar{x}	22.9	22.0	21.5	25.3	21.9	24.8
	s	3.0	3.5	4.2	5.1	3.0	3.8

a, b = P ≤ 0.05

Higher milk yield of group 2 cows in all the periods of lactation had some influence on the average daily milk yield of fat and protein (table 3). The yield of these milk constituents in group 2 was significantly higher when compared to the results obtained when the cows received

conserved feeds (group 1). In early lactation, the average daily fat and protein yield was 235 and 200g higher, respectively, than in group 1, and after day 200 these results were higher by 218 g (32%) for fat and 214 g (35.6%) for protein.

The values of the biochemical indices analysed in cows' blood serum can be found in table 4. The feeding system had no significant effect on the content of glucose, triglycerides and total cholesterol in the cows' blood serum. Nevertheless, slightly higher levels of glucose and cholesterol were determined in the blood serum of cows fed on pastures (group 2) versus group 1 cows, especially in the first (to day 100) and second (to day 200) lactation period.

Pasture grazing of cows (group 2) resulted in an increased level of blood (BUN) and milk urea nitrogen (MUN). The highest significant differences ($p < 0.05$) were observed in the first phase of lactation. The concentration of BUN at that time was 36% higher and that of MUN – 42% higher in group 2 versus group 1. In the next lactation periods the level of those two indices in group 2 was higher by 18% on average. In all periods of lactation the activity of AST and ALT enzymes in group 2 was slightly higher (table 4). In both feeding groups the activity of AST was the highest during the first 100 days of lactation.

Discussion. The feeding ration containing pasture green fodder was characterised by 17% higher total protein content and 11.5% BTJ content in d.m. compared to the feeding ration composed of conserved feeds. The higher milk yield determined for cows grazing on pasture (group 2) may have resulted from a higher intake of protein, including PDI. According to Bargo *et al.* (2002), pasture green fodder frequently varies in its composition and nutritive value. This in turn causes changes in the amounts of dry matter eaten by cows, which in consequently can decrease milk yield capacity. High yielding cows grazing on pasture alone, with no additional fodders, are unable to attain their potential milk yields (Bargo *et al.*, 2003). Therefore, to maintain high milk yields from cows fed on pasture it is necessary to use additional fodders in the amounts adequate to the quality and nutritive value of the pasture green fodder (Buckley *et al.* 2000). As the results of our study imply, the pasture feeding system had a favourable effect on the efficiency of feeding expressed by the kilos of FCM milk per 1 kg DM of the feeding ration. Müller and Fales (1998) state that this usually helps reduce milk production costs and increase profit obtained when cows graze on pasture.

Studying some protein and energy metabolism indices obtained from blood serum analyses revealed that the level of glucose in both groups of cows was within the physiological norm for dairy cows (Winnicka, 2002). This can indicate that the energy needs of the cows were fulfilled during all subsequent lactation periods. Dhiman *et al.* (1991) suggest that there is a strong relationship between the energy value of a feeding ration and the content of glucose in cows' blood. As the authors suggest (Iwańska *et al.* 1999, Brzózka *et al.* 2000), the slightly higher, albeit statistically not confirmed, concentration of glucose in blood serum of group 2 cows could favour the higher milk yield of the cows grazing on pasture. Pasture feeding had a positive effect on the level of cholesterol in blood serum. It was found that compared to group 1, the level of cholesterol in group 2 cows was on average 12%

higher, which can be a good prognostic of the cows' future fertility (Pysera and Opałka 2000, Bronicki 2001).

One of the indices for the evaluation of the feeding of cows, and high yielding cows in particular, is the concentration of urea in blood and milk (Roseler *et al.*, 1993, Chládek 2002). According to Minakowski *et al.* (2003), monitoring of the level of blood and milk urea can serve as an easily accessible source of information on the balancing of a feeding ration used in cows' nutrition and proper supply of protein with the required share of the rumen degradable (RDIP) and non-degradable protein fraction (RUIP). It can be assumed that increased concentration of protein in pasture green fodder had an effect on the significantly higher blood serum urea content (BUN). This was confirmed by the significantly elevated amount of urea in milk (Succii and Crovetto, 1996; Nardonei Valfare, 1999). At the same time it should be emphasised that in all the cows examined the level of urea in milk varied from 183 to 289 mg/l (which corresponds to 3.04 – 4.81 mmol/l). The optimum milk urea level is 150-250 mg/l (Paulicks, 1992) or 250-350 mg/l (Brzózka *et al.* 2000). Oltner and Wiktorsson (1983) state that, if taken the feeding system is proper, the concentration of urea in milk should not exceed 5 mmol/l.

Another factor indicating how the nitrogen supplied in a feeding ration is used is the concentration of blood urea nitrogen (BUN). Roseler *et al.* (1993) and Harris (1996) suggest that any values of BUN above the general level of 12 or 16-18 mg/dl, respectively, imply insufficient or excessive protein supply in a feeding ration and reflect nitrogen loss, decreased milk synthesis, often lower technological value of milk and problems in reproduction. The results of the authors' own studies show that the BUN level in cows grazing on pasture (group 2) was within the proper range (13.89 – 16.02 mg/dl). On the other hand, the BUN in cows fed conserved feeds (group 1) (11.02 -13.65 mg/dl) can suggest an insufficient concentration of protein in a feeding ration, especially for cows in the first period of lactation.

The high content of available nitrogen compounds in pasture green fodder could have some effect on the dynamics of nitrogen metabolism in the liver, which can be confirmed by an elevated activity of AST and ALT enzymes in the blood serum of group 2 cows. Similar relationships were reported by Iwańska *et al.* (1999). However, the differences found between the groups in the present study were not statistically significant.

Conclusion. To summarise the results of the present study, it needs to be said that for Holstein-Frisian cows yielding ca 6 thousand kg of milk, pasture feeding helps improve milk yield better than the feeding of conserved feeds. Increased milk yield performance of cows is accompanied by elevated levels of urea in milk. The basic chemical composition of milk does not undergo any major (evident/clear/obvious) changes. However, the daily fat and protein yield is higher in cows which receive pasture green fodder.

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