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EFFECT OF ORGANIC AND CONVENTIONAL FEEDING OF RED-AND-WHITE COWS ON PRODUCTIVITY AND MILK COMPOSITION

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Abstract

The aim of the study was to determine the degree to which organic feeding of dairy cows under the natural conditions of the Carpathian Foothills, compared to conventional feeding, will affect the yield, composition and fatty acid content of milk, some blood metabolites and reproductive indicators. The experiment was carried out with 24 Red-and-White × Holstein-Friesian Red cows (67.5% HF on average) during the period from 3 weeks before calving to 44 weeks of lactation. Cows were assigned to two analogous groups (with 12 animals per group) subjected to different feeding regimes (O – organic, C – conventional). In group O, the basic roughage was meadow grass silage in winter and pasture forage in summer. In group C, it was maize silage all year round. In both groups, these feeds were supplemented with meadow hay, concentrate and mineral-vitamin mixture, and in the conventional feeding group additionally with wilted grass silage, brewers' grains and ensiled maize grain. The rations were formulated according to IZ-INRA standards (2001). Chemical composition and intake of feeds, body weight, body condition and milk yield, and selected reproductive indicators were recorded. The milk was analysed for the content of basic nutrients, fatty acids and CLA. Blood serum was assayed for the concentration of free fatty acids, beta-hydroxybutyric acid, glucose, urea, albumins and aspartate aminotransferase. Average feed cost per production of 1 kg milk was determined in addition to the botanical composition, yield and intake of pasture sward in the organic herd. It was found that the organic feeding of cows with the lactation yield of about 7000 kg reduced the milk yield (by about 9–15%) compared to group C. Cows from group C also had a higher milk protein and casein content (by about 0.15 percentage units) compared to group O. Cows from group C were also characterized by higher maximum milk production at the peak of lactation and better lactation persistency as well as smaller body weight and body condition losses in the first period of lactation compared to animals from group O. No significant differences in the content of selected blood metabolites or reproductive indicators were found between the groups. The milk of cows from group O had a significantly higher content of *n-6* and *n-3* PUFA and CLA as well as a narrower ratio of *n-6* to *n-3* PUFA.

Key words: dairy cows, feeding, milk yield and chemical composition, blood metabolites, fertility

Organic animal breeding is one of innovative technologies for complex food production, which maintains a balance between production and environment (Kristensen and Struck Pedersen, 2001). Most milk production farms in Poland continue to use standard (conventional) systems for feeding dairy cattle (Bilik and Strzetelski, 2005). Because of the increasingly high expectations of the consumers for health value of food (Nałęcz-Tarwacka, 2006), organic milk production modelled on European Union (Council Regulation (EC) No 834/2007) and Polish regulations (Journal of Laws, 2009, No 116, item 975) is beginning to expand. Long-term comparative studies (Byström et al., 2002; Roesch et al., 2005; Nauta et al., 2006) have shown that compared to organic farms, conventional farms have a much greater potential for choosing proper roughages and concentrates in terms of nutritive value, which enable more optimal energy and protein balancing of the diets for high-yielding dairy cows. A study by Gruber et al. (2000) in Danish dairy cattle farms with an average stocking density of 87 cows showed no significant differences in health parameters between cows having similar lactation yields (about 6000 kg milk) and fed according to organic or conventional principles. However, it was found that cows from organic farms had slightly lower fertility, probably as a result of lower energy levels in the rations used during lactation. Other studies (Fall et al., 2008; Slots et al., 2009) demonstrated that the risk of poorer reproductive indicators and metabolic disorders does not increase significantly when the permitted energy deficit is less than 20 MJ NEL/day in the first and 15 MJ NEL/day in the second month of lactation. Feeding cows having a lactation yield of 6,000–7,000 kg milk with balanced rations at the level of tolerated energy deficit in the first period of lactation has no significant effect on reducing milk yield when feeding roughages of high quality (Knaus et al., 2001). In Poland, there is a shortage of studies thoroughly investigating the effect of organic feeding of current dairy cows on milk yield and composition and on metabolic and reproductive indicators.

The aim of the study was to determine the degree to which organic feeding of Red-and-White × Holstein-Friesian Red cows under the natural conditions of the Carpathian Foothills, compared to conventional feeding, will affect the yield, composition and fatty acid profile of milk, the content of some blood metabolites, and reproductive indicators.

Material and methods

Experimental design, feeding and housing of animals

The study was carried out with 24 Red-and-White cows (RW × Holstein-Friesian Red) from 3 weeks before calving to 44 weeks of lactation. Animals were assigned to two analogous groups (with 12 cows per group) according to precalving body weight, lactation number, percentage of HF Red genes, 305-day lactation yield, and expected calving date. The average proportion of Holstein-Friesian genes (HF Red) in the herd of experimental cows was 67.5%. The rations (Table 1) and percentage composition of concentrate mixtures (Table 2) were formulated according to IZ-INRA standards (2001) using INRAtion software ver. 3.23 (2006). Cows' body weight and stage of production cycle were accounted for when formulating the rations. The basic roughage was maize silage in the conventional group (C) and wilted meadow grass silage in winter and pasture forage in summer in the organic group (O). In both groups, these feeds were supplemented with meadow hay, concentrate and mineral-vitamin mixture, and in the conventional feeding group additionally with wilted grass silage, brewers' grains and ensiled maize grain. Cows from the organic group (O) were fed according to the principles based on European Union standards and regulations (EU Verordnung, 1999), assuming that:

– roughages from permanent grasslands (forages, silages, hay) will form at least 60% of ration DM, and concentrates not more than 40% DM in the first period of lactation (weeks 1 to 13) and 25% in the second (weeks 14 to 44);

Table 1. Daily rations

Group	Feeds	Period of experiment					
		before calving		lactation (weeks)			
		3 weeks		1 to 13		14 to 44	
		Amount of feed/day					
		DM (kg)	% ration DM	DM (kg)	% ration DM	DM (kg)	% ration DM
C	Maize silage	3.70	31.84	7.70	35.16	6.20	33.64
	Grass silage	1.40	12.05	4.00	18.26	2.70	14.65
	Meadow hay	0.50	4.30	0.60	2.74	1.85	10.04
	Barley straw	1.90	16.35			-	
	Brewers' grains			1.70	7.78	1.19	6.46
	Ensiled maize grain	1.80	15.49	2.80	12.79	1.65	8.95
	Concentrate mixture*	2.32	19.97	5.10	23.29	4.84	26.26
Complete diet (TMR)		11.62	100.0	21.90	100.0	18.43	100.0
Desired milk production level (kg/day)[1]		x		31		24	
O	Winter period:						
	meadow grass silage	6.80	52.30	11.40	53.02	10.80	55.96
	meadow hay	3.10	23.85	3.10	14.42	3.60	18.65
	concentrate mixture *	3.10	23.85	7.00	32.56	4.90	25.39
Complete diet (TMR)		13.00	100.0	21.50	100.0	19.30	100.0
Desired milk production level (kg/day)		x		28		24	
	Summer period:						
O	pasture forage	6.50	56.03	13.00	57.78	13.00	66.67
	meadow hay	1.50	12.93	2.00	8.89	2.50	12.82
	barley straw	0.80	6.90	1.00	4.44	1.00	5.13
	concentrate mixture*	2.80	24.14	6.50	28.89	3.00	15.38
Conventional diet		11.60	100.0	22.50	100.0	19.50	100.0
Desired milk production level (kg/day)		x		32		25	

*For % composition, see Table 2.

[1] When meeting the requirement for UFL, PDIN, PDIE, Ca and P (acc. to IZ INRA standards, 2001).

– legume seed meals (e.g. field pea or field bean) will be fed instead of semi-finished products from oilseeds, from which oil was extracted chemically (extracted soybean or rapeseed meal);

– the nutrient content of daily ration will meet the requirement of cows with specific body weight and the desired milk production level, with acceptable (tolerated) energy deficit not exceeding 15% in the first period of lactation. All the roughages and concentrates fed in group O will come exclusively from organic farming, and the feed (mineral-vitamin) supplements will be certified for use on organic cattle farms.

Cows were fed twice daily, and feed intakes and feed refusals were recorded. Complete rations (TMR) were fed to cows from the conventional group (C) during the whole year and to cows from the organic group (O) during the winter period. During summer, cows from the organic group were fed in a rotational pasture system (for 9 h on average, from 0800 to 1700). Herbage yield and intake of pasture sward were determined in each paddock and a representative forage sample was taken for analysis. During the pasture feeding period, cows were supplemented indoors with concentrate (twice daily: before turnout to pasture and after returning from pasture) and meadow hay (once daily after evening feeding), and with cereal straw on pasture. During grazing, animals had constant access to drinking water (from a water cart) and salt licks with trace elements.

Animals were kept in loose barns with straw-bedded lying boxes, milking, milk storage and feed preparation rooms, and feeding and dunging/access passages. Barns were equipped with automatic watering troughs, and gravitational supply and exhaust ventilation.

Table 2. Percentage of components in concentrate mixtures

Components	Composition of mixture (%)		
	C	E_s (summer)	E_w (winter)
Ground wheat	27	30	20
Ground barley	18	35	25
Ground triticale	9		
Ground oats		30	29
Soybean meal	18		
Rapeseed meal	10		
Rapeseed expeller	10		
Pea meal			20
Ground limestone	2.5	2	2.5
Fodder salt	1.0	1	0.5
Vitamin-mineral preparation (Blatin TMR-MIX)	2		
Sodium bicarbonate	1.5		
Brewer's yeast	1		1
Organic mineral-vitamin mixture (Blatin R18 ADE)		2	
Organic mineral mixture MM Land (Opolferm Grodzisk)			2

Table 3. Chemical composition and nutritive value of feeds

Feed	Dry matter (%)	Content in DM (%)						Content in 1 kg of feed DM		
		ash	crude protein	ether extract	crude fibre	N-free extractives	NDF	UFL	PDIN (g)	PDIE (g)
Conventional feeding (gr. C)										
maize silage	29.20	4.48	8.59	3.97	19.83	63.13	52.6	0.83	52.1	65.4
grass silage	37.50	11.16	13.31	3.21	24.41	47.61	57.0	0.75	75.0	65.0
ensiled maize grain	58.10	1.26	8.20	4.61	2.38	83.55	9.5	1.22	56.3	66.9
meadow hay	85.20	9.23	9.11	1.78	29.59	45.69	55.7	0.66	59.2	71.0
barley straw	87.70	5.61	4.46	2.06	44.34	43.53	73.5	0.42	22.3	44.2
fresh brewers' grains	23.63	4.25	27.84	8.35	16.06	43.50	45.0	0.84	206.0	179.3
concentrate mixture C[1]	88.24	5.82	19.67	1.34	3.13	70.04	17.0	1.09	156.1	131.2
TMR (for dry period)	46.40	7.47	10.70	3.64	19.81	58.38	43.0	0.84	72.0	75.0
TMR (for 1st lactation period)	40.22	7.57	12.70	4.02	17.45	58.26	39.0	0.88	93.0	90.0
TMR (for total lactation period)	41.85	7.67	13.40	4.30	18.56	56.07	39.9	0.85	94.0	91.0
Organic feeding (gr. O)										
pasture forage[2]	22.25	7.08	16.76	3.68	21.78	50.70	51.0	0.82	97.1	87.5
meadow grass silage	40.07	10.38	14.20	3.72	34.40	37.10	49.8	0.77	76.3	63.0
meadow hay	85.49	7.08	8.25	1.31	34.23	49.13	59.4	0.73	65.5	75.7
forage straw	86.90	5.83	3.98	1.97	46.34	41.88	74.5	0.43	23.4	45.8
concentrate mixture E_s[1]	88.63	4.14	11.95	1.82	8.43	71.48	17.5	1.11	84.1	94.5
concentrate mixture E_w[1]	88.25	5.62	14.25	1.52	5.30	73.31	17.4	1.05	89.1	91.5
TMR (for dry period)[3]	54.34	7.89	12.80	3.87	21.20	54.24	44.4	0.80	77.0	73.0
TMR (for 1st lactation period)[3]	53.75	7.55	13.30	4.21	18.23	56.71	40.6	0.81	79.0	74.0
TMR (for total lactation period)[3]	52.65	7.76	13.00	4.25	19.70	55.29	43.4	0.80	77.0	73.0

[1] For percentage components in concentrate mixtures, see Table 1.

[2] Composition of pasture sward (%): red fescue 14, perennial ryegrass 14, meadow fescue 11, Westerwolds ryegrass 8, timothy 8, Italian ryegrass 6, tall fescue 5, smooth-stalked meadow grass 4, white clover 14, Egyptian clover 8, lucerne 6, others (herbs and weeds) 2, average green forage yield: 180–220 q/ha.

[3] Applied in winter period.

Content (% DM) of organic acids (lactic, acetic and butyric) in silages and pH of silages (respectively): whole crop maize – 5.68, 1.40, 0.14 and 3.87; grasses – 3.25, 1.47, 0.16, and 4.70; meadow sward (grasses and legumes) – 3.33, 1.27, 0.21 and 4.50; crushed maize grain – 3.82, 1.02, 0.21 and 4.00.

Measurements, chemical analyses and statistical calculations

Chemical composition and intake of feeds, body weight, body condition, milk yield and chemical composition, and average feed cost (total and per kg milk) were recorded during the experiment. Analysis was also made of the fatty acid and CLA content of milk, some blood metabolites, and reproductive indicators. In addition, botanical composition of pasture sward and percentage of different species of grasses, legumes, herbs and weeds in the sward were determined. Pasture yield and forage intake by the cows were determined using the difference method by comparing pasture forage biomass before and after grazing, following Różycki's standard control parcel method. The measurements were taken at 5 sites of each paddock by hand cutting of forage from the area marked with a wooden frame (1 m × 1 m) at a height of 3–5 cm. After gathering, the forage was mixed by hand and a representative sample was taken for chemical analyses. Dry matter was determined in fresh matter, and the other nutrients after drying the sample at about 60°C for 48 h.

The intake of feed (TMR) by the cows during the indoor feeding period (during the whole year in group C and in winter in group O) was determined by weighing total amounts of feed offered to all cows per group and feed refused. Weighings were made for 2 consecutive days at the third and last weeks of the experiment before calving and at 1, 5, 13 and 21 weeks after calving. Basic chemical composition of the feeds was determined by the standard procedure (AOAC, 1995), NDF in roughages according to Goering and Van Soest (1970), and silage pH using an Elwro N 5170 potentiometer. The acetic and butyric acid content of the silages was determined using a Varian 3400 gas chromatograph (column CP-WAX 58, 25 m, 0.53 mm, 1.0 micron with FID detector, 260°C, range 11, helium as carrier gas, 6 ml/min, injection temperature 200°C) using a Varian 8200 CX autosampler. Butyric acid in silages was determined by high-performance liquid chromatography (HPLC) after centrifugation of water filtrates with 24% metaphosphoric acid using a Shimadzu chromatograph (column Nucleosil 250/4 – C 18, detector UV-Vis SPP-6 AV and autosampler SIL-10 AX).

Body weight and body condition were determined 7 days before expected calving and 7, 35, 90 and 150 days postcalving. Body weight was determined by weighing the animals in the morning at the same hour, before feeding. Body condition score (BCS) was estimated independently on a 5-point scale by 2 or 3 evaluators in accordance with DEFA recommendations (2001). The mean of individual scores served as the ultimate score.

Cows were milked twice daily in the milking parlour and the amount of milk drawn from every cow was determined weekly using TRU-TEST milk meters. Representative samples of milk (means from two milkings) were collected every two weeks to determine its chemical composition. Milk samples were preserved (GROPOL), chilled and stored until analysis in a freezer (–20°C) for about two weeks. The fat, crude protein, casein, lactose and urea content of milk was determined using a Milko-Scan FT 120 (Foss Electric). The profile of fatty acids and CLA in milk samples was determined by gas chromatography, using the same gas chromatograph as for determination of VFA in the silages.

Blood for analyses was collected from all animals 7 days before and after calving. Free fatty acid (FFA) and beta-hydroxybutyric acid (BHBA) content was determined by the enzymatic-colorimetric method using a Cobas-Bio automatic analyser (ROCHE) at 37°C and a wavelength of 550 nm for FFA and 340 nm for BHBA. FFA were determined using standard reagents: WAKO Chemicals USA, FFA C test Kit and ACS-ACOD method, while BHBA was determined using RANDOX, RANBUT, Cobas MIRA and HANT-PROD Warsaw reagents. The level of glucose, urea, albumins and aspartate aminotransferase (AspAT) was determined by dry colorimetric technique using a KODAK analyser (VITROS 250 Chemistry).

Reproductive indices of the cows were determined based on insemination index (services per conception), conception rate (pregnancy rate after first insemination), insemination interval (number of days between first treatment and pregnancy) and calving-to-conception interval (days). The course of parturition was scored on a 3-point scale: spontaneous (no assistance), intermediate (moderate assistance) and complicated (veterinary assistance) (Pirlo et al., 1997).

Statistical calculations for body weight, body condition, milk yield, milk constituents, blood metabolites, some reproductive indicators and fatty acid content of milk fat were performed by one-way analysis of variance (ANOVA) using SAS package (1996). Significance of differences between the groups was determined using Fisher's test. The other results (feed intake and feed costs) were not analysed statistically because of the group feeding of the cows. For this reason, these results are approximate as they only show the means calculated by dividing these values by the number of animals in a given feeding group.

Results

The chemical composition and nutritive value of the feeds, expressed using the INRA system, are given in Table 3. The data show that the nutrient content and nutritive value of the roughages and concentrates corresponded to the parameters characterizing feeds of average or good quality (Kański et al., 2005). Feed and nutrient intake values are presented in Table 4. These data indicate that in both groups, the mean daily intake of dry matter during 3 weeks before calving and in the analysed lactation periods was at a similar level to the values determined in the rations for the desired milk production levels.

The body weight and body condition of the cows 7 days before expected calving and at 7, 35, 90 and 150 days of lactation did not differ significantly ($P>0.05$) between the groups (Table 5). The organic group (O), however, was characterized by greater body weight and body condition losses of the cows after calving compared to animals from group C.

The milk yield of lactating cows averaged 7010 kg (22.3 kg/day) of milk, which contained 3.97% fat, 3.29% protein, 2.75% casein, 4.81% lactose and 200.2 mg/l urea (Table 5). Although there were no statistically significant ($P>0.05$) differences between the groups in milk productivity, cows from group C achieved higher daily milk yield in the first and total periods (by 8.9 and 15% on average) compared to group O. In the first period of lactation, cows from group C also had higher ($P>0.05$) protein (by 0.16 units on average) and casein contents (by 0.14) than in group O.

Group C was also characterized by higher maximum milk production at the peak of lactation and better lactation persistency (Figure 1).

Table 4. Mean daily intake of feed and nutrients by the cows

Group	Item	Period of experiment		
		before calving	lactation (weeks)	
		3 weeks	1–13	14–44
C	Winter and summer period:			
	TMR (kg)	24.8	50.1	43.2
	dry matter (DM) (kg)	11.5	20.2	18.1
	crude protein (CP) (g)	1231.3	2565.4	2425.4
	PDIN[1] (g)	828.0	1878.6	1701.4
	PDIE[2] (g)	870.0	1818.0	1647.1
	UFL[3]	9.6	17.8	15.4
O	Winter period:			
	TMR	23.1	40.0	37.6
	DM	12.5	21.5	19.8
	CP	1605.4	2859.2	2574.0
	PDIN	965.6	1698.4	1524.6
	PDIE	917.0	1591.0	1445.4
	UFL	9.9	17.4	15.8
	Summer period:			
	pasture forage (kg)	29.1	58.3	58.3
	meadow hay (kg)	1.8	2.3	2.9
	barley straw (kg)	0.9	1.1	1.1
	concentrate mixture (kg)	3.2	7.3	3.4
	DM (kg)	11.6	22.5	19.5
	CP (g)	1577.7	3292.1	2843.0
	PDIN (g)	996.0	1988.0	1727.0
	PDIE (g)	1002.0	1986.0	1691.0
	UFL	9.5	18.8	15.9

[1, 2, 3] – acc. to IZ INRA (2001).

Feed and nutrient use for the production of 1 kg milk and daily feed costs are presented in Table 6. The data suggest that regardless of the feeding system, the efficiency of feed utilization for milk production depended on lactation period and milk production level. Compared to the total lactation period, lower feed use per kg of milk produced was found in the first period of lactation. A similar relationship was also found for feed cost per kg milk, which was about 15–18% lower in the first compared to the total period of lactation.

When analysing the serum content of metabolites, no significant differences were found between the groups (Table 7), although in cows from group C lower values were observed 7 days after calving compared to group O. Cows from group O were characterized by a higher insemination index after the first insemination, lower number of services per conception, and a shorter calving interval compared to group C (Table 7). Parturitions were generally normal in both groups and veterinary assistance was only necessary in single animals.

Table 5. Cows' body weight and condition, milk yield and chemical composition

Item	Group		SEM	P
	C	O		
Body weight (kg):				
before calving (7 days)	687.3	684.5	38.65	0.86
after calving (days):				
7	618.3	613.5	38.23	0.76
35	597.6	584.3	39.82	0.17
90	586.5	571.0	38.01	0.12
150	602.8	583.1	39.52	0.15
Body condition (BCS, pts.):				
before calving (7 days)	3.67	3.66	0.29	1.00
after calving (days):				
7	3.43	3.39	0.33	0.76
35	3.30	3.17	0.34	0.19
90	3.23	3.11	0.38	0.18
150	3.39	3.23	0.28	0.16
Milk yield (kg):				
total (1-44 weeks)	7353.4	6666.7	1080.7	0.16
daily by period (weeks):				
1–13	31.8	29.2	4.09	0.13
14–44	21.4	18.6	3.59	0.14
1–44	24.0	21.4	3.58	0.08
Milk nutrient content (%) during lactation (weeks):				
1–13				
solids	12.41	12.32	0.98	0.41
fat	3.96	3.86	0.21	0.35
protein	3.44	3.28	0.20	0.13
casein	2.82	2.68	0.18	0.10
lactose	4.79	4.82	0.11	0.72
urea (mg/l)	197.4	215.4	33.22	0.22
14–44				
solids	12.42	12.40	1.20	0.51
fat	3.99	4.05	0.19	0.50
protein	3.24	3.21	0.16	0.13
casein	2.78	2.71	0.19	0.38
lactose	4.77	4.84	0.11	0.72
urea (mg/l)	183.8	204.2	28.88	0.11

The fatty acid content of milk is shown in Table 8. No statistically significant ($P>0.05$) differences were found between the groups in the content of saturated fatty acids (SFA), unsaturated fatty acids (UFA) and monosaturated fatty acids (MUFA), nor in the content of $C_{16:0}$, DHA and UFA/SFA ratio. Compared to the conventional group (C), the milk obtained from cows from the organic group (O) had a significantly ($P<0.01$ or $P<0.05$) higher content of *n-6* and *n-3* PUFA (including $C_{18:3}$ *n-6*, $C_{18:3}$ *n-3* and EPA) and sum of CLA isomers as well as a narrower *n-6/n-3* PUFA ratio. Milk samples from pasture-fed cows were characterized by a more beneficial fatty acid profile and CLA content that was almost half as high compared to the milk of cows from the same group during the winter feeding period (Figure 2).

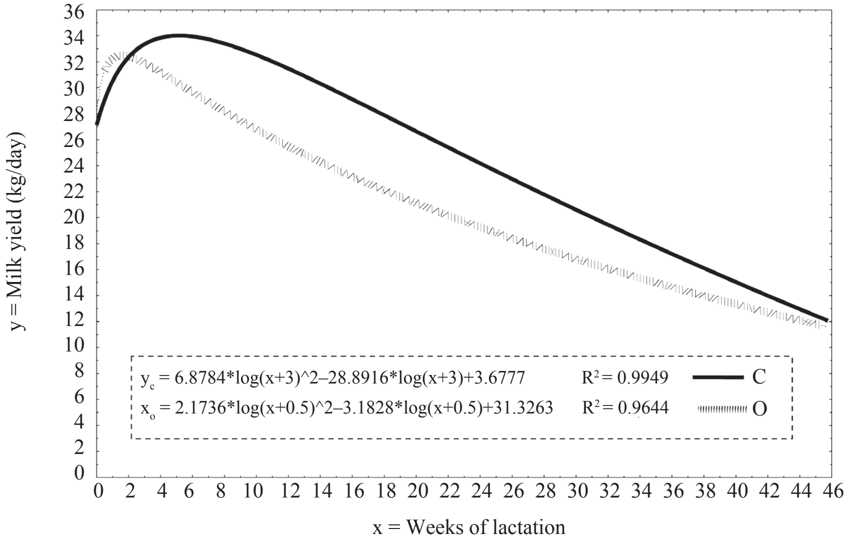

Figure 1. Changes in mean daily milk yield of cows by week of lactation

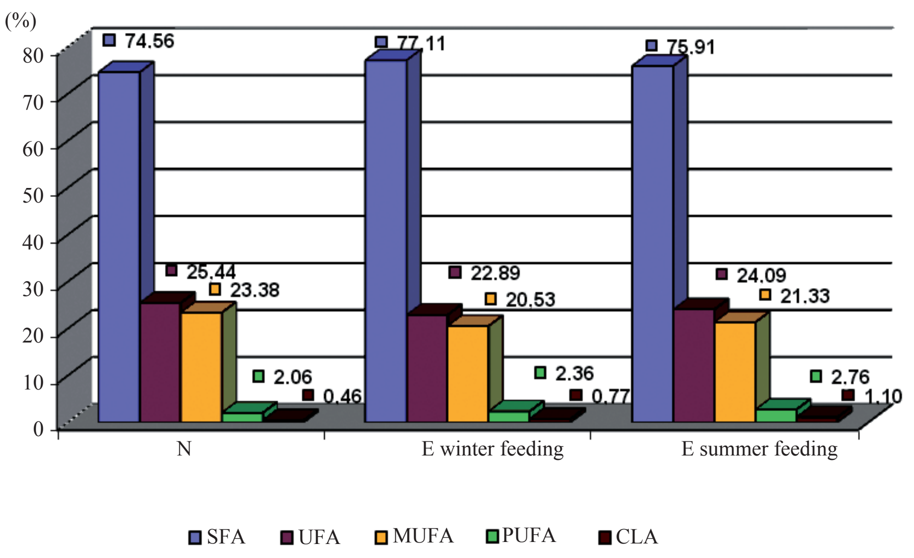

Figure 2. Fatty acid content (% of FA) in milk of cows under conventional (group C) and organic feeding (group O) during winter and summer

Table 6. Mean daily feed and nutrient use per kg milk and feed costs

Group	Item	Lactation (weeks)	
		1–13	14–44
C	Winter and summer period:		
	TMR (kg)	1.58	2.01
	dry matter – DM (kg)	0.63	0.84
	crude protein – CP (g)	83.8	113.3
	PDI (g)	57.2	77.0
	UFL	0.56	0.72
	Total feed cost/day (zloty)[1]	14.34	11.38
	Feed cost/kg milk (zloty)	0.45	0.53
O	Winter period:		
	TMR (kg)	1.37	2.02
	DM (kg)	0.74	1.06
	CP (g)	97.9	138.3
	PDI (g)	54.5	77.7
	UFL	0.59	0.85
	Total feed cost/day (zloty)[1]	13.73	12.13
	Feed cost/kg milk (zloty)	0.47	0.65
	Summer period:		
	pasture forage (kg)	2.07	3.13
	meadow hay (kg)	0.08	0.16
	forage straw (kg)	0.04	0.06
	concentrate mixture (kg)	0.26	0.18
	DM (kg)	0.80	1.05
	CP (g)	116.7	152.8
	PDI (g)	70.42	90.91
	UFL	0.67	0.90
	Total feed cost/day (zloty)[1]	9.88	7.35
	Feed cost/kg milk (zloty)	0.34	0.40

[1] Cost of feeds (zloty/kg) acc. to Experimental Station of the National Research Institute of Animal Production Grodziec Śląski Ltd.:

group C – maize silage 0.20, grass silage 0.18, meadow hay 0.28, barley straw 0.13, ensiled maize grain 0.42, fresh brewers' grains 0.058, concentrate mixture 0.91 (including: rapeseed expeller 0.70, ground grains 0.70, maize grain 0.43, soybean meal 1.57, rapeseed meal 0.85). 1 kg TMR = 0.275–0.286.

group O – grass legume silage 0.23, pasture forage 0.065, meadow hay 0.35, forage straw 0.15, cereal concentrate mixture (summer) 0,70, cereal-legume mixture (winter) 0.75, organic mineral-vitamin mixture 4.58, mineral mixture 1.91. 1 kg TMR = 0.360–0.373.

Table 7. Content of some metabolites in blood serum and reproductive indicators

Item	Group		SEM	P
	C	O		
1	2	3	4	5
Before calving (day 7):				
NEFA (mml/l)	0.26	0.42	0.224	0.17
BHBA (mml/l)	0.58	0.53	0.125	0.33
glucose (mml/l)	3.69	3.71	0.473	0.96
urea (mml/l)	3.45	3.61	0.579	0.52
albumins (g/l)	30.9	29.4	2.523	0.18
AspAT (U/l)	79.3	72.5	15.360	0.32

Table 7 – contd.

1	2	3	4	5
After calving (day 7):				
NEFA (mml/l)	0.71	0.92	0.398	0.23
BHBA (mml/l)	0.94	1.28	0.518	0.15
glucose (mml/l)	3.15	3.48	0.566	0.18
urea (mml/l)	3.32	3.68	1.000	0.42
albumins g/l)	29.9	31.1	4.989	0.59
AspAT (U/l)	114.7	123.7	26.128	0.46
Insemination index	2.22	2.17	1.37	0.78
Pregnancy rate after first service (%)	25.0	33.3		
Insemination interval (days)[1]	48.5	43.8		
Calving interval (days)	143.0	131.1	20.8	0.34
Course of parturition[2] (no. of cows):				
S – spontaneous	7	9		
I – intermediate	3	3		
C – complicated	2	1		

[1]Time in days from first insemination after calving to conception.

[2]On a 3-point scale: S – spontaneous (no assistance); I – intermediate (moderate assistance); C – complicated (veterinary assistance).

Table 8. Fatty acid content of milk (% of total FA)

Fatty acids	Groups		SEM	P
	C	O[1]		
SFA (total)	74.56	76.51	5.882	0.468
$C_{4:0}$	17.07 a	14.82 b	2.342	0.046
$C_{16:0}$	36.75	34.58	3.748	0.212
$C_{18:0}$	7.74 a	6.16 b	1.468	0.027
UFA (total)	25.44	23.49	5.882	0.468
MUFA (total)	23.38	20.93	5.746	0.353
PUFA (total)	2.06 B	2.56 A	0.332	0.003
$C_{18:3}$ *n-6*	0.004 B	0.116 A	0.055	0.0002
$C_{18:3}$ *n-3*	0.241 b	0.347 a	0.838	0.041
EPA	0.012 b	0.032 a	0.018	0.022
DHA	0.009	0.013	0.014	0.481
PUFA *n-6*	1.335 b	1.383 a	0.095	0.048
PUFA *n-3*	0.262 b	0.392 a	0.068	0.042
PUFA *n-6/n-3*	5.100A	3.528B	0.528	0.008
UFA/SFA	0.341	0.310	0.115	0.629
CLA[2]	0.462 B	0.918 A	0.241	0.0005

[1]In group O, mean values for the winter and summer periods are given.

[2]Sum of CLA isomers: c9t11; t10c12; c9c11; t9t11 or other compounds with the same retention times as those of the isomers.

Discussion

Feed intake values during the last three weeks before calving indicate that the organic feeding of cows caused no differences in daily intake of dry matter and nutrients compared to conventional feeding. Likewise, Yang et al. (1999) reported no effect of the type of ration fed during the prepartum period on feed intake by the cows. This shows that feed intake during this period can be largely manipulated through factors other than feeding, especially the animal's metabolic and hormonal factors (Morrison et al., 2001).

Maintaining the optimum condition and body weight of periparturient cows determines their "healthy" transition from late gestation to early lactation (Mulligan et al., 2006). The body condition scores obtained in the present study for cows prior to calving are close to the recommended standards (3.2–3.75 BCS) for dairy cows entering the dry period (Domecq et al., 1997). Also the body condition and body weight losses observed in both groups in the first period of lactation are generally consistent with the values recommended by Domecq et al. (1997) for dairy cows. The greater body weight and condition losses in cows from the organic group (O) were probably due to the fact that this group had a higher energy deficit in the first period of lactation and mobilized greater body fat reserves during this period compared to the conventional group (C). Similar observations were also made by other authors (Trachsel et al., 2000; Roesch et al., 2005), who showed that changes in body condition depend largely on the energy balance of the cows during different stages of lactation.

The feeding level of cows in different periods of the production cycle affects the level of metabolic processes and the yield and chemical composition of milk (Borkowska et al., 2006). The results for milk yield of the cows under conventional feeding (group C) confirm, to a certain extent, the long-term findings of some authors (Byström et al., 2002; Roesch et al., 2005; Nauta et al., 2006) that the proper balancing of dietary energy and protein and appropriate selection of feeds in terms of quality and palatability in different stages of the production cycle have an effect on lactation persistency and overall milk yield. It follows from the observations of the authors cited above that in conventional breeding systems, there is much greater scope for choosing appropriate wet roughages and concentrates in terms of energy value, which enable a more optimal balancing of the rations for energy. It can therefore be speculated that the higher milk yield in the first and in the total period of lactation, found in cows from the conventional (C) compared to the organic (O) group, was due to the higher concentration of energy (UFL) and protein (PDI) in the ration and better protein protection from ruminal degradation. It cannot be excluded that wet roughages and concentrates used in conventional feeding of cows are better digested (Bowman et al., 2002), which could have increased nutrient use efficiency for production, without the need for excessive mobilization of body fat reserves (Kung et al., 2000).

As in studies by Roesch et al. (2005) and Nauta et al. (2006), we found no significant effect of the cow feeding methods on milk lactose percentage. The higher milk protein and casein content in cows under the conventional compared to the organic feeding system could result from the more beneficial energy balance and course of fermentation processes in the former group. This is also indicated by the more efficient ruminal synthesis of microbial protein and lower energy losses in cows from the conventional group compared to animals from the organic group. These tendencies did not occur in Swedish organic farms (Toledo et al., 2002), probably because of less severe restrictions concerning the use of some types of processed feeds for dairy cow nutrition in Sweden. In general it can be stated, however, that regardless of the cow feeding system (organic or conventional), the mean values that we found for percentage of basic nutrients and urea in milk were no different from the content of these values in the milk of milk-recorded Polish Holstein-Friesian cows (Borkowska et al., 2006).

When analysing the results for feed and nutrient use per production of kg milk, it can be stated that feeding complete rations (TMR) in the conventional group (C) during the whole year and in the organic group (O) in winter has a more beneficial effect on nutrient utilization compared to pasture feeding. The lower intake of dry matter (DM), energy (UFL) and protein (PDI) in cows from the conventional group compared to those from the organic group was also due to the higher milk yield and concentration of these nutrients in feed.

The fact that serum glucose level prior to calving was close to the physiologically normal level possibly indicates that the energy requirement has been met and the cows were properly prepared for the beginning lactation. The lower serum BHBA and FFA content after calving in cows from the conventional group compared to the organic group shows that the energy deficit in this group was lower. Meanwhile, the lower serum urea content in cows from group C after calving may be indicative of the more optimal supply of rumen degradable protein and energy for bacteria that digest structural carbohydrates (Chládek, 2002). The fact that serum albumin and AST level in cows after calving was close to the physiologically normal level is evidence of normal liver function and proper supply of amino acids in the ration (Reader, 2003).

The results for course of parturition are similar to those reported in the literature for cows maintained in high-yielding dairy herds (Pirlo et al., 1997). Both cow parturitions and the analysed reproductive indicators were within the range considered normal for cows of the breed under study. Also other authors (Roesch et al., 2005; Nauta et al., 2006; Fall et al., 2008) reported no significant differences in the analysed reproductive indicators between the cows from conventional and organic farms, nor did they find significant differences in the length of the period between calving to first insemination, which was similar in both herds and ranged from 96 to 98 days in 75% of the cows. Other studies (Sehested et al., 2003) showed that cows maintained in organic farms were characterized by a longer calving interval compared to those from conventional farms, due to the higher energy deficit of the rations used on organic farms. The slightly more beneficial insemination index that we found in cows from the organic group compared to the conventional group may possibly be attributed to the effects of pasture feeding of the former group in summer and regular turning out of the cows to the outside pen in winter, which made it easier for the attendants to detect oestrus. Also, we cannot exclude the beneficial effect of other environmental factors (movement in fresh air, solar radiation, supply of vitamin A and beta-carotene) on welfare and on reproductive indicators of cows from group O.

Our results obtained for fatty acid profile in milk samples confirm that the type of ration may influence changes in the content of some desirable fatty acids in milk fat. Like in our study in the organic group, other researchers (Slots et al., 2009) observed a beneficial effect of feeding cows with pasture forage and wilted grass silage on the content of *n-3* PUFA and CLA isomers in milk and on reducing the *n-6/n-3* PUFA ratio. One study (Ellis et al., 2007) revealed that the milk from cows fed pasture forage was characterized also by a higher content of antioxidants, vitamins A and E and β-carotene, which together with a narrower *n-6/n-3* PUFA ratio has a beneficial effect on the health value of milk (Carrero et al., 2004). Pasture forage, a rich source of α-linolenic acid ($C_{18:3}$ *n-3*), is also a substrate used for production of trans-vaccenic acid (TVA) and conjugated linoleic acid (CLA), which have an effect on activity of Δ^9-desaturase taking part in the endogenous synthesis of CLA from trans 11 $C_{18:1}$ acid in mammary gland tissues (Lock and Garnsworthy, 2003). This shows that the type of ration influences changes in the rumen, including the biohydrogenation process and the type of fatty acids synthesized by rumen microorganisms during lipolysis and hydrogenation of dietary PUFA into saturated fatty acids with a small number of double bonds. Nevertheless, part of the dietary PUFA bypasses the rumen and may be absorbed and deposited unchanged in mammary gland tissues (Lock and Garnsworthy, 2003). The higher *n-3* PUFA content of milk in cows from group O receiving pasture forage or wilted grass silage compared to animals fed complete rations (TMR) with a high proportion of maize silage resulted from the higher content of $C_{18:3}$ *n-3*, which is the main fatty acid in forage and meadow grass silage in addition to being the precursor for the synthesis of EPA ($C_{20:5}$ *n-3*) and DHA ($C_{22:6}$ *n-3*) in animal products (Marmer et al., 1984). Also the higher CLA content of milk in cows fed pasture forage compared to those receiving silages could result from the better protection of PUFA (including $C_{18:2}$ *n-6*) against ruminal biohydrogenation. It is also possible that the higher CLA content of milk from group O cows receiving pasture forage was due to differences in the content of easily soluble sugars and easily digestible fibre in the forage. Marino et al. (2006) showed that the regulation of rumen processes by the appropriate choice of rations determines the content and the ratio of different fatty acid types in tissues. The milk from cows fed extensively is generally characterized by a higher content of *n-3* PUFA (including $C_{18:3}$ *n-3*) and CLA compared to those fed intensively with concentrate-high diets (Slots et al., 2009). This is because the roughage to concentrate ratio in the ration has an effect on the pH of ruminal fluid and thus on the type of rumen microorganisms that take part in the biohydrogenation and isomerization of unsaturated fatty acids. As a result, it also influences changes in *de novo* synthesis of fatty acids in the mammary gland.

It is concluded that the organic feeding of Red-and-White × Holstein-Friesian Red cows kept under the natural conditions of the Carpathian Foothills and having a lactation yield of about 7000 kg milk, caused their milk yield to be about 10% lower during lactation compared to conventional feeding with complete diets (TMR). Compared to conventional feeding, feeding the cows according to the organic principles significantly increased the content of fatty acids (including CLA in milk) desirable in the human diet. It can be assumed that under favourable production and economic conditions and when meeting certain feed requirements, dairy cattle farming using organic methods can offer an alternative to conventional farming, especially in larger farms.

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KRZYSZTOF BILIK, MAGDALENA ŁOPUSZAŃSKA-RUSEK

Wpływ ekologicznego i normatywnego żywienia krów rasy czb na produkcyjność i skład mleka

STRESZCZENIE

Celem badań było określenie, w jakim stopniu ekologiczne żywienie krów mlecznych w warunkach przyrodniczych Pogórza w porównaniu z żywieniem normatywnym wpłynie na wydajność, skład i zawartość kwasów tłuszczowych mleka oraz wybrane metabolity krwi i wskaźniki rozrodcze. Doświadczenie przeprowadzono na 24 krowach rasy czb × hf Red (śr 67,5% hf) w okresie od 3. tygodnia przed wycieleniem do 44. tygodnia laktacji. Zwierzęta przydzielono do dwóch analogicznych grup (po 12 sztuk), różniących się zasadami żywienia (E – ekologiczne, N – normatywne). Podstawową paszę objętościową w grupie E stanowiła kiszonka z runi łąkowej – w okresie zimowym i zielonka pastwiskowa – w okresie letnim, a w grupie N kiszonka z kukurydzy – w ciągu całego roku. Pasze te w obu grupach uzupełniano sianem łąkowym, mieszanką treściwą i mineralno-witaminową, a w grupie normatywnej dodatkowo: kiszonką z przewiędniętej trawy, młótem browarnianym i kiszonym ziarnem z kukurydzy. Dawki pokarmowe bilansowano według norm IZ-INRA (2001). Kontrolowano skład chemiczny pasz i ich pobranie, masę ciała, kondycję i wydajność mleczną oraz wybrane wskaźniki rozrodu. W mleku oznaczano zawartość podstawowych składników, kwasów tłuszczowych i CLA, a w surowicy krwi stężenie WKT, BHBM, glukozy, mocznika, albumin i AST. Ponadto określano średni koszt paszy na produkcję 1 kg mleka, a w ekologicznym stadzie krów skład botaniczny, wydajność i pobranie runi pastwiskowej. Stwierdzono, że ekologiczne żywienie krów o wydajności laktacyjnej około 7000 kg spowodowało obniżenie wydajności mleka (ok. 9–15%) w porównaniu z grupą N. U krów grupy N wykazano również wyższą (ok. 0,15 jednostek procentowych) zawartość białka i kazeiny w mleku w porównaniu z grupą E. Krowy grupy N odznaczały się także wyższą produkcją maksymalną mleka w szczycie laktacji i lepszą wytrwałością laktacji oraz mniejszymi ubytkami masy i kondycji ciała w pierwszym okresie laktacji niż zwierzęta z grupy E. Pomiędzy grupami nie stwierdzono istotnego zróżnicowania w zawartości wybranych metabolitów krwi, ani we wskaźnikach rozrodu. W mleku krów grupy E wykazano istotnie wyższą zawartość kwasów tłuszczowych PUFA *n-6* i PUFA *n-3*, CLA i bardziej zawężony stosunek PUFA *n-6/n-3*.