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Coverage of nutritional requirements of cows and cost of milk production on farms with different feeding systems

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The aim of this study was to estimate the level of nutrient requirement satisfaction in cows, as well as production costs, milk yield and chemical composition in 46 farms in eastern Poland, which were divided into 3 groups depending on the applied feeding system: group I – extensive system (17 farms), group II – semi-intensive system (17 farms) and group III – intensive system (12 farms). In farms of group I feeding of cows was based on farm fodder obtained from permanent grassland, in group II farms cows were additionally fed maize silage, while cows in group III farms were fed PMR. For each cow an individual theoretical feed ration was calculated according to the INRA system depending on the cow's daily yield on the milk sampling day. A total of 1590 feed rations were prepared, including 755 for the summer feeding period and 835 for the winter feeding period. It was shown that feed rations in farms of group III (intensive system) were best balanced, which was manifested in high milk yields and nutrient contents, particularly fat and protein (P≤0.01). The lowest production cost of 1 kg milk (0.68 PLN) was also recorded in that system, whereas it was highest (0.76 PLN) in group I (extensive system). A slightly higher production cost (0.70 PLN) was generated in group II of farms (semi-intensive system), in which pasture grazing and maize silage were used. Thus this system may be recommended for farms, which may not invest large financial resources in their modernisation, while they have adequate forage area and are focused on commercial milk production.

KEY WORDS: dairy cows / feeding ration / milk yield / chemical composition of milk / production cost

Intensive milk production is mainly based on the TMR and PMR feeding systems, which application ensures rational cattle nutrition. These strategies are adopted most frequently in farms keeping animals of a high genetic potential for milk production, i.e. Holstein--Friesian cows, which may efficiently increase milk yields with an increase of feed ration supplementation. Apart from the intensive feeding systems based on maize silage and haylage, guaranteeing optimal satisfaction of nutrient requirements in those cows, milk producers – particularly in regions with a high share of permanent grassland, choose nutrition strategies based on fresh forage. Such strategies require lower financial outlays; however, in those systems it is difficult to adequately balance the feed ration and thus reach high milk yields. Proportions between these feeding systems are varied and depend on the land relief, local climatic conditions, as well as the area, which may be used for grazing [5, 12, 18]. The adopted feeding system also affects the chemical composition and biological value of obtained milk. The quantity and quality of milk produced by cows are dependent on many factors, including the size and composition of the administered freed ration, cattle breed, production season, health status of animals or phase of lactation [1, 2, 4, 6, 10, 12, 15, 17].

The aim of this study was to assess the degree of nutrient requirement satisfaction in cows, their productivity and the chemical composition of milk as well as its production costs depending on the feeding system adopted on the farm.

Material and Methods

Analyses within this study were conducted on 46 farms located in eastern Poland, which were keeping Polish Holstein-Friesian Black- and Red-and-White, as well as Polish Black-and-White and Polish Red-and-White cows. Farms selected for these analyses were divided into 3 groups depending on the adopted feeding system: group I – with the extensive feeding system (17 farms), group II – with the semi-intensive system (17 farms) and group III – applying the intensive feeding system (12 farms). In farms of group I feeding of cows was based on farm fodder, which means that in the winter season nutrition was based on hay and haylage administered *ad libitum*, along with a small (1-2 kg) addition of ground grain, while in the summer season cow feeding was based on 24-h grazing on the pasture supplemented with hay (1-2 kg) and ground grain (2-3 kg). In feeding of cows in farms from group II maize silage and a small addition of commercial high-protein concentrates (0.5-1 kg) were additionally used in the winter season, whereas in the summer next to grazing also haylage, maize silage and an addition of commercial concentrates (1-1.5 kg) were administered. Cows in farms of group III were fed in the intensive (PMR) system based on a single formulated ration, composed of maize silage, haylage and an addition of 2-3 kg ground grain – administered ad libitum from a mixer wagon, as well as commercial concentrates – depeding on the cows' productivity. No hay or pasture grazing were used in this feeding system. In each analysed farm grass silage (with dry matter content of min. 45%) was ensiled in plastic bales. All farms were covered by the milk recording programme.

From each cow milk samples from whole milking were individually collected between days 30 and 240 of lactation twice a year, i.e. in the summer season (755 samples) and the winter season (835 samples). Thus a total of 1590 samples were collected, in which contents of fat, protein and solids were determined (Infrared Milk Analyzer; Bentley Instruments).

For each farm a questionnaire was filled in, specifying farm area, land area and cropped area, head count of cattle, including dairy cows, animal housing and feeding systems, particularly organisation of the feed base and nutrition of cows in various seasons of the year, grazing time as well as costs of cow housing and feeding. Based on the collected data an original milk production intensity index was developed specifically for the purpose of this study and presented in the form of a point score

$$\text{Milk production intensity index} = \frac{(2\ x\ kg\ milk\ per\ 1\ cow + 1\ \text{x}\ kg\ milk\ per\ 1\ ha\ MFA^{*})}{3}$$

*MFA – main forage area (agriculturally utilised land with crops intended to be used directly as fodder for cattle),

distinguishing 3 groups of farms:
- <4000 points – extensive production;
- 4000-6000 points – semi-extensive production;
- >6000 points – intensive production.

The adopted formula for farm milk production intensity illustrates the interdependence between productivity of cows and productivity of land. Mean productivity of cows multiplied by 2 and the volume of milk production per 1 ha MFA were adopted as the main informative index. The total was divided by 3, which gives an averaged result showing milk production intensity in the farm. Farming intensity expressed in the volume of labour inputs and means of production allocated to specific production provides the basis for the classification of a farm as intensive, semi-intensive or extensive [8].

Based on the questionnaire data the following parameters were determined:
– land and cropping structure (%),
– number of livestock units (LU),
– LU per 1 ha utilised agricultural area (UAA) and 1 ha permanent grassland (PGR),
– maize cropped to produce silage (ha/cow)
– grazing time (h)
– production cost structure (%, PLN).

Unit cost accounting was performed following the FADN methodology. Production costs were analysed in terms of their division into direct and indirect costs, which was done depending on their cost centres, i.e. their connection to the product. Direct costs are these components of costs, which may be definitely ascribed to a given activity. The volume of these costs is proportionally related to the scale of production; moreover, they have a direct effect on the size (both volume and value) of production. In turn, indirect costs are these costs, which at the moment of their generation may not be divided into specific products, instead they are common costs for the entire farm. Indirect costs incurred within the operating activity of a farm were divided into types of activities run in the farm, based on the shares in production values of each activity in the total production value of the farm [16].

In each farm samples were collected for analyses of all used farm fodders (i.e. those produced on the farm), i.e. green forage, silage, hay and ground grain, for which their primary chemical composition was determined and their nutritive value was assessed in the INRA system using the PrevAlim 3.23 programme. An individual theoretical feed ration for each cow was developed in the INRA system (the INRAtion 3.3 programme) depending on the daily yield at the milk sampling day. A total of 1590 feed rations were prepared, 755 for summer feeding system and 835 for winter feeding. The energy value of the feed ration was converted into megajoules (MJ), while protein intake was given in grams of ruminally degradable nitrogen and metabolisable protein supply (PDIN and PDIE).

The results were analysed statistically using the StatSoft Inc. STATISTICA ver. 8 programme based on one- and two-way analysis of variance. Mean values for individual traits and standard deviations were calculated. The significance of differences between means for the investigated groups was determined using the Duncan test for farms, while for samples it was with Tukey's test for various n.

Results and Discussion

Farms from group I may be classified as small farms, with the mean cattle herd size of 14.47 head at the yield per lactation of 3943.86 kg milk (Table 1). The production intensity index amounted to 3660.75 points, which indicates that they were farms with typically extensive milk production. Low efficiency of milk production resulted mainly from the land structure, with the predominance of permanent grassland (84.44%) and no maize grown. At such a land structure feeding has to be based on pastures. Daily grazing time in those farms was on average 16.25 h, thus it may be assumed that cows grazed for 24 h with breaks only for milking and grooming. This confirms a high share (approx. 80%) of feeds originating from permanent grassland in the diet of the cows: in the summer 70.26% from the pasture and 11.78% from hay, while in the winter 60.02% from haylage and 20.91% from hay (Tables 2 and 3). The other 20% feed ration were supplied by ground grain. In the feeding systems based on fodders from permanent grassland we observe considerable problems with energy-protein balance [12]. This is also confirmed by the results of this study, in which the difference in the satisfaction of requirement between energy and protein in the summer exceeded 20% (MJ 96.62%, PDIN 117.50% and PDIE 120.85%), while in the winter it was 10% (MJ 97.39%, PDIN 108.94% and PDIE 106.66%).

Farms classified to group II have a semi-intensive milk production system (4619.48 points). The mean number of cows in the herd was 26.03 head, mean yield was 4754.28 kg milk, permanent grassland (PGR) in the land structure accounted for less than ½ area (48.14%), with maize grown on some of the arable land (12.58% UAA). The area cropped to maize for silage per 1 cow was 0.21 ha. As a rule the animals grazed on the pasture all day, i.e. from the morning milking to the evening milking (7.89 h). The share of fodder from grassland in the summer was 65% (pasture 36.74%, hay 9.93%, haylage 18.36%), while in the winter it was only 44% (hay 7.92% and haylage 36.18%). The share of maize silage in the summer was as low as 14.23%, while in the winter it was the main feed in the feed ration at 34.97%. Concentrates, similarly as in farms of group I, covered only approx. 20% nutrient requirements of cows, while commercial feeds were also added (7.53% in the summer and 5.38% in the winter). In that group in the summer feeding disproportions were also observed in the energy-protein balance; however, an addition of maize silage amounting to several percent resulted in an improvement of that balance (MJ 99.24%, PDIN 109.46% and PDIE 111.87%), which was found to be significant at $P \leq 0.01$. In the

Table 1
General characteristics of the surveyed farms

Specification		Group of farms I (n=17)	Group of farms II (n=17)	Group of farms III (n=12)
Intensity index for milk production (pts.)	x SD	3660.75^{Aa} 998.87	4619.48^{Ab} 968.97	7377.46^{B} 1528.21
Milk yield per lactation (kg)	x SD	3943.86^{Aa} 1155.04	4754.28^{Ab} 896.69	7357.65^{B} 749.15
Number of cows (heads)	x SD	15.47^{A} 5.67	26.03^{B} 10.19	56.42^{C} 15.27
Agricultural land (ha)	x SD	21.05^{Aa} 7.43	52.08^{Ab} 66.02	71.12^{B} 39.95
Share of main forage area (%)	x SD	85.54^{a} 21.56	65.34^{B} 14.85	81.97^{a} 13.41
Share of grasslands (%)	x SD	84.44^{A} 8.39	48.14^{A} 19.26	36.62^{B} 43.36
Stocking (LU) per 1 ha of agricultural lands	x SD	1.00^{a} 0.26	0.95^{a} 0.27	1.28^{b} 0.47
Stocking (LU) per 1 ha of grasslands	x SD	1.22^{A} 0.47	1.98^{B} 0.74	2.90^{C} 1.10
Grazing time (h)	x SD	16.25^{A} 5.16	7.89^{B} 4.71	– –
Share of pasture feeding in daily ration (%)	x SD	66.00^{A} 13.69	35.14^{B} 23.34	– –
Share of maize crops in agricultural lands (%)	x SD	– –	12.58^{B} 6.07	38.62^{C} 11.79
Maize crops area/cow (ha)	x SD	– –	0.21^{B} 0.17	0.39^{C} 0.05
Share of maize silage in the daily ration (%)	x SD	– –	33.92^{B} 6.08	36.73^{C} 1.98

a, b – differences significant at P≤0.05
A, B – differences significant at P≤0.01

winter feeding period the feed ration for cows from that group turned out to be properly balanced.

Farms from group III had a typically intensive production system (7377.46 points), the number of cows was on average 56.42 head at the mean yield of 7357.65 kg milk. In that farm group stocking of animals was significantly higher both when presented per 1 ha UAA (1.28 LU) and per 1 ha permanent grassland (2.90 LU) (P≤0.01). Arable land predominated in the land structure (63.38%) and it was mainly cropped to maize for ensiling, with the area cropped to maize per 1 cow at 0.39 ha (P≤0.01). Throughout the year cows were fed a uniform diet, in most farms in the form of PMR administered ad libitum, con-

Table 2

Composition and energy and protein coverage of nutritional ration depending on feeding system in the summer season

Type of fodder		Group of farms I (n=17)				Group of farms II (n=17)				Group of farms III (n=12)			
		energy (MJ)	protein PDIN	protein PDIE	coverage of ration (%)	energy (MJ)	protein PDIN	protein PDIE	coverage of ration (%)	energy (MJ)	protein PDIN	protein PDIE	coverage of ration (%)
Number of samples	No.	145				314				296			
Pasture	x	66.47^{A}	964.79^{A}	929.34^{A}	70.26^{A}	38.22^{B}	587.98^{B}	556.97^{B}	36.74^{B}	–	–	–	–
	SD	18.78	371.94	337.50	11.51	23.03	400.67	343.34	21.70	–	–	–	–
Maize silage	x	–	–	–	–	16.00^{A}	135.54^{A}	179.32^{A}	14.23^{A}	48.92^{B}	403.76^{B}	547.28^{B}	35.55^{B}
	SD	–	–	–	–	14.57	122.39	161.41	12.66	7.85	68.69	94.72	3.12
Hay	x	7.97	96.92	124.11	9.67	8.53	117.56	128.91	9.93	–	–	–	–
	SD	9.54	133.52	147.04	11.78	15.54	209.44	228.29	18.89	–	–	–	–
Haylage	x	–	–		–	19.20^{A}	262.23^{A}	258.92^{A}	18.36^{A}	44.59^{B}	698.72^{B}	577.10^{B}	32.34^{B}
	SD	–	–		–	17.16	211.98	214.03	17.19	10.11	116.30	94.72	6.50
Farm concentrates	x	18.81^{A}	223.19^{A}	247.70	20.06^{A}	13.13^{B}	140.89^{B}	164.66^{B}	13.20^{B}	13.85^{B}	146.79^{B}	172.76^{B}	10.52^{C}
	SD	8.88	116.81	116.86	7.91	10.03	106.24	125.44	9.58	9.06	95.05	112.57	7.09
Commercial concentrates	x	–	–	–	–	9.30^{A}	171.54^{A}	143.54^{A}	7.53^{A}	29.77^{B}	618.72^{B}	515.39^{B}	21.59^{B}
	SD	–	–	–	–	14.12	269.58	220.37	10.64	11.92	204.66	162.04	8.39
Total	x	93.25^{A}	1284.90^{A}	1301.16^{A}	100	104.39^{B}	1415.75^{B}	1432.33^{B}	100	137.13^{C}	1867.99^{C}	1812.52^{C}	100
	SD	15.11	338.96	291.98		18.04	377.20	263.31		14.08	201.66	111.09	
% coverage requirement	x	96.62^{A}	117.50^{A}	120.85^{A}		99.24^{B}	109.46^{B}	111.87^{B}		106.55^{C}	105.17^{C}	100.84^{C}	
	SD	6.42	13.20	11.06		5.34	11.67	7.28		7.00	8.75	5.36	

A, B, C – differences significant at $P \leq 0.01$

Table 3
Composition and energy and protein coverage of nutritional ration depending on feeding system in the winter season

Type of fodder		Group of farms											
		I (n=17)				II (n=17)				III (n=12)			
		energy (MJ)	protein		coverage of ration (%)	energy (MJ)	protein		coverage of ration (%)	energy (MJ)	protein		coverage of ration (%)
			PDIN	PDIE			PDIN	PDIE			PDIN	PDIE	
Number of samples	No.	162				361				312			
Maize silage	x	–	–	–	–	32.65^{A}	284.67^{A}	376.44	34.97^{A}	51.74^{B}	420.45^{B}	573.64	36.81^{B}
	SD	–	–	–	–	7.38	69.17	95.51	5.19	5.97	52.31	66.71	1.80
Hay	x	16.96^{A}	235.64^{A}	255.95^{A}	20.91^{A}	6.50^{B}	92.34^{B}	100.26^{B}	7.92^{B}	–	–	–	–
	SD	8.01	128.24	118.92	11.55	6.31	97.63	99.99	9.25	–	–	–	–
Haylage	x	48.67^{A}	702.81^{A}	621.53^{A}	60.02^{A}	33.67^{B}	547.10^{B}	482.96^{B}	36.18^{B}	44.00^{C}	710.53^{A}	566.30	31.36^{C}
	SD	11.31	197.05	150.20	11.89	10.26	148.68	121.03	11.03	6.31	113.33	93.46	3.50
Farm concentrates	x	15.89^{A}	190.77^{A}	218.52^{A}	19.06^{A}	14.73^{A}	157.02^{B}	186.06^{B}	15.55^{A}	10.02^{B}	107.52^{C}	125.43^{C}	7.81^{B}
	SD	6.43	67.51	79.64	5.59	5.14	51.90	62.69	4.22	12.12	130.98	151.98	9.94
Commercial concentrates	x	–	–	–	–	5.45^{A}	189.24^{A}	154.47^{A}	5.38^{A}	34.47^{B}	701.84^{B}	581.56^{B}	24.02^{B}
	SD	–	–	–	–	4.95	169.56	146.74	4.77	12.61	170.37	150.98	8.10
Total	x	81.52^{A}	1129.22^{A}	1095.99^{A}	100.00	92.99^{B}	1270.37^{B}	1300.19^{B}	100.00	140.23^{C}	1940.34^{C}	1846.94^{C}	100.00
	SD	16.46	267.84	222.04		13.48	273.05	255.17		11.43	133.94	87.98	
% coverage requirement	x	97.39^{A}	108.94^{A}	106.66^{A}		102.35^{B}	100.10^{B}	102.91^{B}		104.29^{C}	105.92^{C}	101.25^{C}	
	SD	10.50	4.72	5.70		8.50	9.52	8.49		4.21	5.29	3.22	

A, B, C – differences significant at $P \leq 0.01$

taining maize silage (35.55% in the summer and 36.81% in the winter), haylage (32.34% in the summer and 31.36% in the winter) and a 10% addition of ground grain. Commercial concentrates at 21.59% in the summer and 24.02% in the winter were fed individually in the mobile feed station depending on the daily yields of cows (Tables 2 and 3). Feed rations were calculated for the mid-lactation of the cows. Despite high milk yields no problems were observed in the energy-protein balance and feed rations were properly balanced.

Low-producing farms are characterised by a high share of grassland in the main forage area (MFA) and a limited use of concentrates. In this case production intensity was assessed at 4000 points, which shows that cows produce milk mainly from concentrates, while concentrate is administered only at peak lactation at an amount up to approx. 0.5% body weight. In turn, semi-intensive farms comprise a group of farms using quality roughage in feeding of cows, along with concentrates administered at a maximum amount of approx. 1% body weight of those cows. In that period maize silage and haylage were the main concentrates in the animal diet and they were used all year round when the animals were not grazing. The adopted production intensity threshold was established at 6000 points, assuming that it is possible to satisfy the nutritional needs of cows using fodder produced in the farm and supplemented with extracted meals. Farms with the intensive production system require a specialist approach both to nutrition and production of quality forage. When fed quality forage cows may produce approx. 20 kg milk, while the rest of milk yield is produced from concentrates. Most frequently cows are kept throughout the year in housing facilities and they are fed a uniform diet with a high share of concentrate mixes administered at maximum amounts of approx. 2% body weight. Additionally, at high yields protein and protected fat are used in the feeding regime along with energy additives in order to satisfy nutrient requirements for the production exceeding 35 kg milk per day per cow [7, 9].

Cows fed following model III in both seasons produced the greatest amounts of milk (27.69 kg in the summer and 28.32 kg in the winter), with the product characterised by the highest contents of milk solids (13.48% in the summer and 13.31% in the winter), including fat (4.44 and 4.34%, respectively), crude protein (3.65 and 3.58%) and casein (2.77 and 2.67%) – Table 4. Productivity of cows fed following models I and II was significantly lower ($P \leq 0.01$) in both seasons, with greater differences between the models recorded in the winter season. It needs to be observed that cows from group I in the winter season produced the lowest amounts of milk (13.25 kg), i.e. over 2-fold less in comparison to animals from group III (28.32 kg). The effect of a more intensive feeding system (a more specifically balanced feed ration) on an increase in milk yields of cows was also confirmed by Bilik and Łopuszańska-Rusek [3] and Morales-Almaráz et al. [14]. In the opinion of Mackle et al. [13], in the case of animals grazing in the pasture the supplementation of their feed ration with maize grain and/or haylage results in an increase in productivity, which was also recorded in this study. Cows fed following model II (in comparison to model I) produced by 2.25 kg ($P \leq 0.01$) more milk (Table 4). This dependence was also confirmed by correlation coefficients between the share of haylage in the feed ration and daily yield: in the summer $r=0.42$ and in the winter $r=0.21$ (Table 5). Moreover, high correlation coefficients were recorded for the share of commercial concentrate, amounting to $r=0.67$ and $r=0.69$, and for maize silage at $r=0.60$ and $r=0.65$, respectively.

Table 4
Yield and composition of cow milk in the summer and winter season in the analyzed feeding group (x and SD)

Specification	Number of samples		Milk yield (kg)		Fat (%)		Protein (%)		Dry matter (%)	
	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter
Group of farms										
I	145	162	17.49^{A**}	13.25^{A**}	3.84^{Aa}	3.98^{A}	3.42^{A*}	3.29^{A*}	12.63^{A}	12.71^{A}
			5.65	4.47	0.50	0.51	0.39	0.37	0.74	0.77
II	314	361	19.74^{B**}	16.37^{B**}	4.03^{Ab**}	4.29^{B**}	3.43^{A}	3.47^{B}	12.79^{A**}	13.19^{A**}
			7.22	6.83	0.62	0.54	0.43	0.36	0.93	0.78
III	296	312	27.69^{C}	28.32^{C}	4.44^{B}	4.34^{B}	3.65^{B}	3.58^{C}	13.48^{B}	13.31^{B}
			5.96	7.44	0.55	0.56	0.41	0.47	0.82	0.97
Interaction										
Production season x feeding system			0.000		0.000		0.003		0.000	

a, b, A, B – differences between feeding groups within season
a, b – differences significant at $P \leq 0.05$; A, B – differences significant at $P \leq 0.01$
*, ** – differences between seasons within feeding group

Table 5

Correlation coefficients (r) between share of energy in feeding ration from chosen fodder (MJ) and content of analyzed milk components

Specification	Type of feed					
	pasture	maize silage	hay	haylage	farm concentrates	commercial concentrates
			Summer			
Daily yield (kg)	–0.36**	0.60**	–0.39**	0.42**	–0.25**	0.67**
Fat (%)	–0.35**	0.33**	0.01	0.25**	–0.17**	0.43**
Protein (%)	–0.17**	0.13*	0.10*	0.10*	0.01	0.13*
Dry matter (%)	–0.36**	0.31**	0.06	0.26**	–0.09	0.34**
			Winter			
Daily yield (kg)	–	0.65**	–0.53**	0.21**	–0.16**	0.69**
Fat (%)	–	0.16**	–0.09	–0.18**	–0.05	0.11*
Protein (%)	–	0.19**	–0.13**	–0.18**	0.02	0.14**
Dry matter (%)	–	0.18**	–0.12*	–0.19**	0.04	0.11*

* – differences significant at P≤0.01; ** – differences significant at P≤0.001

According to many authors [2, 3, 5, 14, 15], the composition of the feed ration is a significant factor influencing changes in the chemical composition of milk. The poorest source of nutrients (both in the summer and winter) is provided by milk obtained from cows kept in farms from group I, i.e. in the summer mainly grazing on the pasture and in the winter fed hay and haylage. Negative correlation coefficients were shown between these feeds and milk solids content, in the summer r=−0.36 for grazing, in the winter r=−0.12 for hay and r=−0.19 for haylage. The highest contents of these nutrients were found in milk of cows fed following model III, with the greatest share of maize silage. In comparison to milk of cows from group I, it contained significantly greater amounts of milk solids (dry matter) ranging from 0.60 to 0.85% (depending on the production season), including fat from 0.36 to 0.60% and crude protein from 0.21 to 0.29%. These dependencies are confirmed by correlation coefficients between both maize silage (summer r=0.31, winter r=0.18) and commercial feeds (summer r=0.34, winter r=0.11) and milk solids content. Moreover, significant seasonal differences were observed for contents of solids and fat in milk of cows from group II and for protein content in milk of cows from group I. Kruczyńska [11] reported that maize silage promotes synthesis of bacterial protein in the rumen and has a positive effect on its level in milk. In turn, Nahar et al. [15] stated that feeding cows with green forage together with concentrates results in an increase of solids contents in milk, including protein and fat.

Table 6
Cost of milk production

Specification		Group of farms		
		I (n=17)	II (n=17)	III (n=12)
The cost of keeping a cow (PLN)	x	2609.31[A]	2870.61[A]	4689.04[B]
	SD	636.47	1002.07	1399.43
The cost of milk production (PLN)	x	0.76	0.70	0.68
	SD	0.30	0.26	0.17
The share of feed in direct costs (%)	x	60.56[a]	62.54	72.07[b]
	SD	19.99	13.32	6.17
The cost of feeding a cow (PLN)	x	1022.71[A]	1152.30[A]	2498.55[B]
	SD	524.27	578.19	830.72
The share of purchased feed in direct costs (%)	x	22.99[A]	24.39[A]	40.07[B]
	SD	18.52	11.31	8.94
The cost of purchased feed/cow (PLN)	x	419.15[A]	465.00[A]	1405.69[B]
	SD	387.03	324.63	623.44

a, b – differences significant at $P \leq 0.05$
$P \leq 0,01$ – differences significant at $P \leq 0.01$

Grazing on the pasture for 24 h a day and a high share of fodder coming from grassland in the farms from group I generated low costs of animal keeping per 1 cow (Table 6). In group I it was only 2609.31 PLN and it was significantly lower than in groups II (2870.61 PLN) and III (4689.04 PLN) ($P \leq 0.01$). High animal management costs in group III resulted first of all from the high share of feeding costs in direct costs (72.07%), which was 2498.55 PLN per 1 cow; these costs were by 60% higher than in group I ($P \leq 0.01$). In order to provide properly balanced feed rations for high-producing cows in group III large amounts of commercial feeds were used, which caused 3-fold greater costs than that in groups I and II ($P \leq 0.01$). Cows from farms in group III produced the largest amounts of milk and as a consequence the cost of its production in that group was lowest (0.68 PLN), whereas the highest cost was recorded in group I (0.76 PLN); these differences were statistically non-significant. Production cost of 1 kg milk in group II (semi-intensive system), in which grazing and maize silage were used, amounted to 0.70 PLN and it was by only 0.02 PLN higher than in group III. Thus it may be recommended for the farms, which may not invest large capital resources in farm modernisation, while they have a considerable forage area and the farmers are interested in commercial milk production.

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