Scientific Annals of Polish Society of Animal Production - Vol. 8 (2012), No 2, 69-78

Effect of addition of wheat DDGS, as employed in rate for cows during the first stage of lactation on milk yield and composition, chosen technological parameters and biochemical blood indicators*

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The aim of the study was to verify whether the substitution of 10% dry matter of roughage in the basal ration with wheat dried distillers grain with solubles (DDGS) has an advantageous effect on the milk yield and chemical composition in cows in their 1st phase of lactation. The experiment was conducted on 50 Polish Holstein-Friesian cows with mean milk yield of 8200 kg in the lactation preceding the experiment. Cows were divided into two groups of 25 head each. Both groups of cows were fed the same basal ration of roughage, composed of maize silage, grass silage, ensiled sugar beet pulp, ensiled maize and wheat grain and an addition of straw. In the experimental group 10% dry matter in the basal ration were replaced with the same amount of wheat DDGS. In both groups the same breeder mash was used, composed of ground wheat, soybean meal, linseed cake and protein concentrate, which accounted for 50% DM in the feed ration. Prior to the experiment and next after 30 and 90 days of the experiment productivity of cows was analysed, milk samples were collected and its composition was determined, together with casein fractions, SCC, bacterial counts and selected physico-chemical and technological parameters of milk. After 30 and 90 days of the experiment blood samples were collected from cows for analyses of selected biochemical indexes – glucose, crude protein, albumins and urea. No statistically significant differences were found in any of the investigated parameters either after 1 month or 3 months of the experiment.

KEY WORDS: wheat DDGS / milk cow / stage of lactation / milk yield / milk composition

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***The study was a part of research project R12 059 03 financed by the Ministry of Science and Higher Education**

With an increase in bioethanol production from grain the use of DDGS obtained by drying distillers grains is gaining in popularity in animal production. They are feeds of high nutritive value for ruminants. They contain considerable amounts of protein and digestible fibre readily available for ruminants, while in the case of maize DDGS they also provide considerable amounts of fat. As a result various DDGS in feed rations for ruminants may replace not only concentrates, but at adequate balacing of structural fibre they may partially replace also roughage [4, 16, 23, 29]. Wheat distillers grain pulp, rich in protein with greater ruminal digestibility in comparison to maize DDGS, contains less fat and more fibre, thanks to which its energy value is lower [18, 23, 24].

Thanks to the high protein contents DDGS may be applied in the feed ration for cattle as a substitute of high-protein feeds, e.g. rapeseed meal. Wheat DDGS applied in the feed ration for dairy cattle may thus be a source of protein. In view of this aspect and protein decomposition in the rumen, this feed may be used e.g. in feed rations for cattle at the beginning and peak of lactation, when the nutrient requirement of cows is high [10]. By substituting a portion of roughage with wheat DDGS we increase protein content in the feed ration, while at the same time considerably reducing NDF content, of which distillers grain pulp is a rich source. It is also necessary to ensure an adequate structure of the feed ration.

The objective of DDGS application in the feed ration was to enhance its nutritive value by increasing the content of crude protein, which was achieved by replacing a portion of the basal ration with wheat DDGS.

Material and Methods

The experiments were conducted in two stages. In the first stage wheat DDGS replaced protein components in the breeder mash for cattle in complete lactation [2]. In the second experiment, discussed in this study, wheat DDGS was used to replace 10% dry matter in the basal ration.

The experiments were conducted on a farm in Stogi in a stanchion barn on Polish Holstein-Friesian Black-and-White cows with mean herd productivity in the lactation preceding the experiment amounting to 8200 kg milk.

For this experiment 50 cows were selected, being in the initial period of lactation – on average 30 days ±15. Animals were divided into two groups: group I – the control and group II – experimental (2 x 25 head), selected as analogues taking into consideration such traits of cows as age and lactation rank, as well as milk yield in the previous lactation.

All the cows were fed identical basal rations, which contained the following shares of individual components in 1 kg fresh matter: 28% maize silage, 43% grass silage, 7% ensiled sugar beet pulp, 5% ensiled maize grain, 3% ensiled wheat grain, 6% dried sugar beet pulp and 8% straw, respectively. Animals in both the groups also received identical breeder mash, containing ground wheat, soybean meal, linseed cake and protein concentrate. The shares of the basal ration and breeder mash in kg dry matter of the feed ration in the control group were 50:50%. In turn, in the experimental group 10% dry matter wheat dried distillers grain with solubles DDGS was introduced in order to replace 10% dry matter of the basal ration. The share of the breeder mash remained identical to that administered in the control.

At the beginning of the experiment feed samples were collected to determine their chemical composition and nutritive value (according to INRA). Their composition and nutritive value are given in Table 1. The rations were balanced according to INRA.

Table 1

Chemical composition and nutritional value the components of feed ration

Specification	Basal ration of roughages	Concentrate	Wheat DDGS
Dry matter (g)	448	876	931
Crude protein (g/kg DM)	135	205	358
Crude fibre (g/kg DM)	232	68	153
NDF (g/kg DM)	477	173	325
ADF (g/kg DM)	311	68	162
UFL	0.87	1.2	0.85
PDIN (g/kg DM)	55	140	226
PDIE (g/kg DM)	69	132	143

At the beginning of the experiment, after 30 and then after 90 days milk yields were recorded, milk samples were collected to analyse its composition, along with casein fraction, SCC and bacterial count. After 30 and 90 days of the experiment blood samples were collected to determine selected biochemical indexes: glucose, crude protein and urea.

The chemical composition of feeds was analysed by standard AOAC methods [1]. The nutritive value of feeds and feed rations was calculated with the INRAtion 3.x programme. Milk parameters, i.e. solids, crude protein, crude fat and lactose were determined by infrared spectrophotometry on a Milko-Scan FT-120 apparatus, the casein fraction was assayed according to Laemmil [12] and Kim and Jimenez-Flores [9], while SCC and bacterial count - using a Somacount 150 apparatus (Bentley). The physico-chemical milk parameters included acidity determined with a pH meter, thermal stability by the ethanol method [22], milk coagulation by the rennet method according to Storch [3]. Biochemical parameters of blood serum were determined by spectrometry in a Vitros analyser, the Etachem DT-60-II system with a set of slides (Johnson & Johnson Clinical diagnostics).

Results were analysed statistically using ANOVA in a unifactorial system using the Statgraphies 6.0 Plus programme.

Table 2
Composition and nutritional value of feed rations

Specification	Control (group I)	Experimental (group II)
	% of dry matter	
Basal ration of roughages	50	40
Wheat DDGS	–	10
Concentrate	50	50
	Nutritional value 1 kg of DM	
Crude protein (g)	163	181
Crude fibre (g)	179	175
NDF (g)	380	373
ADF (g)	233	226
UFL	0.97	0.97
PDIN (g)	82	92
PDIE (g)	89	84

Results and Discussion

Introduction of DDGS to the feed ration at the simultaneous reduction in the share of roughage resulted in an elevation of crude protein and PDIN contents in kg DM of the feed ration. Due to the high fibre content in DDGS no marked reduction was observed in crude fibre or NDF and ADF in dry matter of the feed ration (Table 2). However, there is a certain risk of a deterioration in the structure of the experimental feed ration and a decrease in the share of effective NDF. The share of straw was the factor stabilising the control and experimental feed rations in terms of their appropriate structure.

Information on productivity of cows, including milk production and its composition, is presented in Table 3.

Data on yields of cows after 30 and 90 days of the experiment showed no statistically significant differences between the groups. Similarly, no significant differences were found in terms of mean yields between the groups with progress in lactation. However, we may observe a trend towards a greater milk production in the experimental group. This is particularly evident during the analyses for samples collected at 90 days from the onset of the experiment, when yield was by 8% higher. No significant effect on fat and protein contents in milk was recorded for the experimental fed ration. Despite a slightly lower fibre content and a higher protein content in the experimental ration (Table 1) no significant reduction of milk fat content was found. Fox and Sweeney [7] reported that both excess protein and fibre deficit in poorly balanced feed rations are factors reducing the level of fat in milk. Results recorded in this study showed no negative effect of the modified experimental

Table 3

Milk yield and chemical composition of milk

Specification		At the beginning of experiment	After one month		After three months	
			group I	group II	group I	groupII
Milk (kg/day)	x	33.0	27.6	28.2	26.3	28.3
	SE	1.59	1.25	1.28	1.30	1.33
Dry matter (%)	x	12.19	12.24	12.68	12.30	12.55
	SE	0.101	0.132	0.099	0.115	0.105
Fat (%)	x	3.82	4.23	4.04	4.12	4.03
	SE	0.251	0.200	0.205	0.236	0.242
Protein (%)	x	3.11	3.19	3.18	3.48	3.38
	SE	0.064	0.064	0.066	0.080	0.082
α-casein (%)	x	–	0.81	0.79	1.10	1.01
	SE		0.022	0.021	0.047	0.044
β-casein (%)	x	–	0.60	0.57	0.64	0.63
	SE		0.025	0.024	0.022	0.021
κ-casein (%)	x	–	0.56	0.52	0.57	0.59
	SE		0.028	0.029	0.023	0.020
Lactose (%)	x	4.56	4.60	4.60	4.80	4.66
	SE	0.034	0.029	0.033	0.039	0.052
Urea (mg/l)	x	230	182	186	169	178
	SE	19.9	16.3	16.7	15.5	17.1
SCC (10^3/ml)	x	218	154	175	191	239
	SE	46.1	28.4	29.1	33.4	34.3

feed ration on fat content in milk. Protein content in milk, which is primarily determined genetically, may have been affected by dietary modifications only to a limited extent [13]. In terms of nutrition it depends mainly on the amount of available energy, as well as the amount and amino acid composition of protein digestible in the small intestine. In the presented study introduction of wheat DDGS to the feed ration had no effect on an increase in the energy value of 1 kg DM, while it only increased protein content, which may have been a factor stimulating milk production, while having no effect on its composition.

Despite statistically unconfirmed differences between the groups in terms of mean values of milk composition parameters observed with progressing lactation both in the experimental group and the control, protein content and its casein fraction, particularly alfa casein, were found to increase. The protein to fat ratio in milk, optimal in terms of milk processability especially for cheese production, is 1:1. A higher ratio results in a deterioration of technological quality of milk [14]. This ratio was similar in milk of both analysed groups. In milk of the control it was 0.75:1 and 0.84:1, respectively, after 1 month and 2 months of the experiment, while in the experimental group it was 0.78:1 and 0.84:1.

Urea level in milk during both measurements was uniform in both groups, which indicates a comparable protein to energy ratio in the feed rations. After 1 month of the experiment, at a protein content in milk below 3.2%, urea level was 182 and 186 mg/l.

This indicates a certain deficit of energy in relation to the requirements of cows. After 3 months of the experiment in both groups, at protein content in milk of 3.38 - 3.48% and urea content of 169-178 mg/l, in the control the protein requirement may be considered as barely satisfying the needs of cows and in the experimental group it may be classified as adequate [19, 20]. No differences between the groups in terms of somatic cell counts and bacterial counts in milk were confirmed statistically. According to the national standard [21], following the EU Directive [6], the admissible limits for processing milk are 100 thousand microbial cells and 400 thousand somatic cells in 1 ml. The somatic cell level over 200 thousand/ml both at the beginning and after three months of the experiment in the experimental group may indicate the onset of inflammation caused by infections [15].

Many studies, in which wheat DDGS was introduced to feed rations for dairy cows, showed no effect of this addition on cows' productivity. In their study Arkuszewska et al. [2], when replacing soybean meal and high-protein concentrate with wheat DDGS in breeder mash for cows in complete lactation reported no effect of the modified feed mix on milk production or its composition. Similarly, Franke et al. [8], when substituting rapeseed meal in the compound feed for cows with wheat DDGS observed no effect of the modified feed ration on milk production or its contents of fat, lactose and urea. However, protein content in milk was lower in the group of cows receiving DDGS in the feed mix. The decrease in milk protein content at the application of wheat DDGS in feed rations for cows was also reported by Schingoethe [23], which associated it with a reduced uptake of lysine and an increased fat content in the feed rations. The high fat content in feed rations with the increased share of maize DDGS was also stressed by Kononoff and Christensen [11], who stated that it may lead to a decreased fat content in milk. In studies by Dunkel [5] and Urdl et al. [26] no effect of the application of wheat DDGS or mixed wheat and barley DDGS was recorded in terms of milk fat and protein contents. In his study Sun [25], when replacing a portion of barley grain in feed rations for cows with wheat DDGS showed no effect of the used DDGS on milk production or its composition. In turn, Zhang et al. [29] substituted wheat DDGS in feed rations for cows to replace a portion of ensiled barley, which together with lucerne hay in the control accounted for 50% DM of the feed ration. Introduction of 20% DM in the form of DDGS to replace silage resulted in an increased intake of feed ration dry matter and greater milk yields, while it had no effect on milk contents of fat, protein and lactose. Introduction of DDGS had no effect on urea content in milk.

Table 4 presents selected physico-chemical parameters as well as technological properties of milk.

To a considerable degree physical quality of milk is dependent on acidity, with elevated acidity being the major cause for a deterioration of thermostability [14]. In the two analysed groups both potential and active acidity of milk meet the requirements of the Polish Standard (PN-A-86002) [21]. No statistically significant differences were found in mean values of potential acidity (SH) and active acidity (pH) as well as the recorded technological parameters, i.e. thermostability and coagulability, between the control and the experimental group after three months of the experiment. Curd cohesion and thermostability are influenced to a much greater degree by genotype rather than environmental conditions. In a two-point scale both coagulability and thermostability were within the upper limits of

Table 4

Features of physicochemical and technological parameters of milk

Specification		At the beginning of the experiment		After three months	
		group I	group II	group I	group II
Potential acidity	x SE	6.9 0.08	6.7 0.09	7.2 0.12	6.9 014
Active acidity	x SE	6.7 0.04	6.6 0.05	6.7 0.09	6.5 0.10
Thermostability[1]	x SE	1.78 0.06	1.85 0.08	1.75 0.09	1.79 0.06
Coagulability[2]	x SE	1.89 0.05	1.82 0.07	1.92 0.06	1.88 0.07

[1]determined by ethanol method PN-68/A-86122 [22] (on a 2-point scale)
[2]determined by the rennet method according to Storch [3] (in a 2-point scale)

the scale in both the groups. Good cagulability and thermostability of milk are required of suitable raw material for cheese making [17, 28].

Table 5 presents values of selected biochemical indexes recorded in blood serum collected from the analysed cows.

Table 5

The selected biochemical parameters of cow blood serum

Specification		At the beginning of experiment		After three months		Reference values*
		group I	group II	group I	group II	
Total protein (g/l)	x SE	75 1.44	74 1.52	81 1.29	82 1.36	51-71
Urea (mmol/l)	x SE	4.4 0.314	4.8 0.332	2.5 0.123	2.8 0.130	1.66-7.47
Glucose (mmol/l)	x SE	2.6 0.097	2.6 0.103	3.3 0.091	3.3 0.096	2.2-4.5

acc. to Winnicka [27]

No statistically significant differences were observed in the biochemical indexes recorded in blood serum between the groups of cows either after 30 or 90 days of the experiment. In both groups of animals throughout the entire study period contents of glucose and urea in blood serum fell within the ranges of reference values reported by Winnicka [27], while crude protein content exceeded these limits, particularly towards the end of the study. The uniform values of biochemical indexes in both experimental groups may indicate comparable utilisation of feed ration nutrients. Similar urea contents in milk and blood of cows in both groups indicate that in the group receiving DDGS, despite higher contents of crude protein in the feed ration, DDGS was effectively utilised by the ruminal microflora.

Also Zhang et al. [29], when introducing wheat DDGS as 20% DM in the feed ration for cows in order to replace barley silage found no effect of applied DDGS on the levels of glucose and urea recorded in blood serum. Similarly, in a study by Arkuszewska et al. [2] the application of wheat DDGS in breeder mash for cows as the main protein component as a replacement of soybean meal and protein concentrate also had no effect on levels of analysed blood biochemical indexes. Likewise, Sun [25], when substituting a portion of barley grain in feed rations for cows with wheat DDGS found no changes in the recorded levels of glucose and urea.

Elevated protein content in the feed ration in the first stage of lactation, due to the replacement of a portion in the basal ration of roughage with wheat DDGS, had no significant effect on milk yields, milk composition, analysed physico-chemical and technological parameters of milk or blood biochemical indexes of the cows.

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