Ann. Anim. Sci., Vol. 15, No. 4 (2015) 929–943 DOI: 10.1515/aoas-2015-0038

EVALUATION OF THE USEFULNESS OF HYBRID RYE IN FEEDING POLISH HOLSTEIN-FRIESIAN DAIRY COWS IN EARLY LACTATION*

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Abstract

The aim of the study was to compare the effect of feeding a hybrid rye grain in rations for dairy cows during the first 100 days of lactation on body condition, milk yield and milk composition. Feeding cows with concentrates containing in its composition 25% or 40% of the ground hybrid rye did not decrease the intake of concentrate or PMR rations as compared to the control group. The introduction of 25% or 40% of the rye hybrid variety *Visello* to the concentrates did not reduce the milk yield of the cows during the first 100 days of lactation. No significant differences in the chemical composition of the milk were observed. The cows fed rye maintained their weight and body condition during the first 100 days of lactation at the same level. The addition of hybrid rye grains in the amount of 25% to concentrate had no significant effect on the fatty acid profile of the milk whereas 40% of rye improved fatty acids composition by decreasing C18:0 and increasing C18:1 *n-9* in the milk.

Key words: rye hybrid, dairy cows, milk yield, milk composition

In recent years, a steady increase in the milk yield of cows in Poland has been observed. However, only about 33–40% of this progress stems from the improvement of the genotype of the cows. The remaining 60–67% is the result of improved nutrition, housing conditions and the use of artificial insemination and new reproductive

*Work financed from: KWS Lochow Polska Ltd., Kondratowice, Słowiańska 5, 57-150 Prusy, Poland.

technologies (Stallings, 2011). The high production potential of modern dairy cows of the Polish Holstein-Friesian breed has caused that traditional feeding systems and herd management have now become ineffective. High yielding cows of this breed require not only better welfare and care conditions, but above all a more precise balancing of feed rations in different periods of the production cycle. So, the key to achieving a high performance and good health of the cows is proper nutrition and especially the use of large doses of concentrates.

In rye hybrid cultivation the phenomenon of heterosis is utilized. Such variations bring an average of 20–25% higher crops than those in population varieties. In rye population varieties there is a community of plants with varying fertility (low, average and highly fertile). In the case of hybrid varieties, the plants are approximately 97–98% homogeneous (Petr and Mikšĭk, 2006).

Unfortunately, rye grain, when compared with other cereals, contains large amounts of antinutritive substances such as resorcinols, non-starch polysaccharides, trypsin and chymotrypsin inhibitors, tannins and pectins, and, in the case of ergot infection, also ergotamines (Grammer et al., 1983; Sosulski et al., 1988; Rakowska, 1994; Kulawinek and Kozubek, 2008). However, in the gastrointestinal tract of adult cattle, most of these compounds (non-starch polysaccharides, tannins, pectins) are degraded by the rumen microorganisms, and in the form of simple compounds are utilized by the animals in the *last part* of the gastrointestinal tract (Ceresnakova et al., 2000; Micek, 2008). It is believed that a high feed intake and poor ration balancing cause tannins to significantly reduce the protein and energy availability of the feed whereas tannins protect proteins against too rapid degradation in the rumen (Śliwiński et al., 2002). Furthermore they prevent flatulence and inhibit the development of gastrointestinal parasites (Novobilsky et al., 2011).

Feeding dairy cattle with rye contaminated with aflatoxins produced by moulds growing on cereals during the growing season or during storage of grain is harmful to the animals' health. Comparative studies examining the risk of contamination with *Fusarium* fungi indicate that, among all cereals grown for grain, rye has the highest resistance to mould and the lowest level of toxins in the grain (Grajewski et al., 2012). However, generally it is believed that the feeding of rye in large quantities to dairy cows may adversely affect the feed intake and milk yield of these animals (Kraszewski and Kozłowski, 2000). There are also indications that rye alters the proportion of fatty acids in milk fat, which lowers its technological usefulness (Kraszewski and Kozłowski, 2000). In the scientific literature there are very few studies using rye, especially the new hybrid varieties which give better yields than the older pollinated varieties – such as *Dańkowskie* or *Antonińskie* – for the feeding of dairy cows and bulls for fattening (Sharma et al., 1981, 1983; Südekum et al., 1994; Brzóska et al., 1999).

The aim of the study was to determine the effect of feeding a hybrid rye grain in rations for dairy cows in early lactation on their yield and the chemical composition of their milk.

Material and methods

Animal management

The experiment was performed at the Pawłowice Experimental Station of the National Research Institute of Animal Production between August 2010 and June 2011. Two separate studies were performed as part of the experiment on dairy cows using different amounts of rye in the concentrate.

Study I was conducted on 60 Polish Black-and-White Holstein-Friesian cows. The animals were chosen from a herd of 460 cows, kept in a curtain-sided barn; the average milk yield of the cows from this herd was 10,500 kg. The animals were divided into 2 groups of 30 animals, taking into account their body weight before calving, sequence of lactation, milk yield during the first 6 days of lactation (at least 15 kg of milk/day) and expected calving date. Both experimental groups were fed the same Partly Mixed Ration 0-PMR, whereas treatments were two types of concentrate fed in the feed stations. The control group K received concentrate without the rye, and the experimental group marked as Z25 was fed concentrate containing 25% grain of the rye hybrid variety *Visello*. Study II differed from study I only by the amount of rye in the mixture – it contained 40% of rye (Z40). The animals in both studies were kept in a free-stall barn equipped with group pens with individual straw-bedded tie-up, with separate feed and manure corridors. In the barn there was a 2×14 herringbone milking parlour.

Experimental design and feeding

The cows were fed according to the PMR system. The composition of the PMRs used in the different studies and groups is given in Tables 3 and 9, and the composition of concentrates in Tables 2 and 8. Diets were balanced according to DLG Recommendations (1997), using WinPasze 3.0 for Windows – WP-A01, professional version MAX (Mroczko and Sobek, 2003). During planning of the daily rations for cows their body weight and the stage of lactation cycle were considered. During the period from 3 weeks before expected calving and until calving all the cows were fed with rations composed to cover the demand of primiparous cows weighing 600 kg, with an assumed level of milk production of 15 kg/day, containing 4% fat and 3.2% protein. After calving, rations were composed to cover the demand of cows weighing about 520 kg with an expected level of production of 30 kg milk/day. The main feedstuffs in the PMR were corn silage and alfalfa silage. The chemical composition of the feedstuffs is shown in Table 1. Concentrates available from feeding stations for groups Z25 and Z40 contained the rye hybrid *Visello* in an amount of 25 and 40% in concentrate, respectively. Cows in both studies were fed twice a day in groups. Concentrate was offered from a feeding station in an amount of 3 kg/day/head for groups K and Z25 in study I and 5 kg for groups K and Z40 in study II. Concentrate was offered during 4 feeding sessions (1/4 of the daily allowance every 6 hours).

Table 1. Chemical composition of feedstuffs used in studies I and II

Feeds	Dry matter (%)	Content in dry matter (%)					
		ash	total protein	ether extract	crude fiber	N-free extractives	NDF
Corn silage	33.48	5.04	9.94	3.94	18.57	62.51	40.1
Alfalfa silage	31.77	11.6	17.62	3.93	29.55	37.30	47.2
GPS (barley)	35.01	5.90	8.11	3.70	26.70	55.60	48.5
Meadow hay	81.58	5.76	9.20	2.34	35.63	47.07	59.6
Grain: corn	87.68	1.48	9.69	4.50	2.10	82.23	15.7
Wheat	84.14	2.37	12.92	1.66	5.60	77.45	16.0
Triticale	86.00	2.21	10.11	1.58	2.63	83.47	24.3
Hybrid rye	87.75	2.74	11.37	2.25	2.35	62.25	20.9
Wheat bran	88.28	4.75	16.87	4.41	9.74	64.23	38.1
Rapeseed meal	90.82	7.26	32.59	5.17	12.99	41.99	30.0
Soybean meal	88.08	7.26	49.95	2.49	5.67	34.63	14.2

Table 2. Composition (%) and nutritive value of concentrates used in study I

Feeds	Share in concentrate (%)		
	concentrate A in PMR	concentrate from feeding station K	concentrate from feeding station Z 25
Wheat, ground	20	89.5	-
Corn, ground	10	-	-
Rye, ground	-	-	79
Triticale, ground	20	-	-
Wheat bran	21	-	-
Rapeseed meal	10	-	10.5
Soybean meal	12	-	-
Limestone	1	1.5	1.5
Monocalcium phosphate	1	1	1
BergaFat	1	1	1
Premix*	4	4	4
Molasses	-	3	3
Sum	100	100	100
	Nutritive value (in 1 kg of dry matter)		
Net energy NEL (MJ)	6.6	7.2	7.0
nBO (g)	152.5	138.7	138.3
Total protein (g)	174.9	112.2	112.86

*Premix Kuh Gold Mineral (Sano), in 1 kg: P – 70 g, Ca – 140 g, Mg – 35 g, Na – 90 g, Cu – 1,000 mg, Zn – 12,000 mg, Mn – 4,000 mg, Vit. A – 1,000,000 UI, Vit. E – 5,000 mg.

Table 3. Composition and nutritive value of the PMR used in study I

Feeds	Group K and Z 25	
	PMR (kg)	PMR (%)
Corn silage	23	51
Alfalfa silage	8	18
GPS barley	5	11
Meadow hay	1	2
Concentrate A	7	16
	Nutritive value (in 1 kg of dry matter)	
Net energy NEL (MJ)	6.58	
Total protein (g)	151.6	
nBO (g)	152.2	

Table 4. Average daily feed intake by cows in study I

Study period (days)	Item	Group	
		K	Z25
1–100	PMR (kg/day)	45.0	45.0
	Concentrate from feeding station (kg/day)	2.98	3.06
	Dry matter – DM (kg/day)	22.5	22.6

Table 5. Body weight and BCS of the cows in study I

Item	Group	
	K	Z25
Body weight at the beginning of the experiment (kg)	550	554
Condition of the body at the beginning of the experiment (BCS, pts.)	3.0	2.9
Body weight at the end of the experiment (kg)	550	553
Condition of the body at the end of the experiment (BCS, pts.)	3.1	3.0

Course of the experiment, measurements and chemical analyses

Both study I and II started three weeks before expected calving and were completed after 100 days of lactation. An initial period lasted from 3 weeks before parturition up to the 6th day of lactation, and the experimental period from the 7th to 100th day of lactation. During the experiment feed intake, body weight and the body condition scores (BCS) of the cows and the yield and composition of milk were determined. Also the fatty acid profile of the milk was analysed.

Feed intake was monitored every week of the experiment for each group. For this purpose the feed amount of PMR was weighed separately for each group and the feed refusals before weighing of the next feeding. Once a month, samples of the PMR and particular feedstuffs, also from feed refusals, were taken for chemical analysis. The basic chemical composition of the feedstuffs was determined using the standard method (AOAC, 1995); ADF and NDF in roughages was determined by the Goering and Van Soest (1970) method.

Body weight and BCS of the animals in the five-point scale were evaluated 3 times on the 7th, 35th, and 100th day of lactation. Prior to the proper experiment the body weight of the cows was also determined 21–25 days before calving, taken under consideration when determining the ration on a three-week period before parturition. Animals were always weighed in the morning, at the same time before feeding. The BCS of the cows was determined by two people, independently of one another, according to the recommendations of DEFA (2001). The final result was the average of the individual ratings.

Milk yield was measured daily throughout the study. Milk samples were collected weekly for chemical analysis (average milk collection during 3 consecutive days of the week) and sent for analysis to the Central Laboratory of the National Research Institute of Animal Production in Aleksandrowice. Milk samples were preserved with 2-bromo-2-nitro-1.3-propanediol (GROPOL), and cooled and stored in the freezer (–20°C) for about two weeks until analysis. The content of fat, total protein, lactose, casein, solids, non-fat solids and urea in the milk was determined using the Milko-Scan FT 120 Foss Electric apparatus. The fatty acid content in the milk was determined by gas chromatography (Varian 3400, RTX 2340, 105 m, 0.32 mm, 0.2 um) using a CX 8200 autosampler (AOAC, 1995).

Statistical analysis and calculations

Data were subjected to one-way analysis of variance and Tukey's range test using Statgraphics Plus (2004). Significance of differences was declared at P≤0.05 and P≤0.01.

Table 6. Yield and chemical composition of milk in study I

Item	Group		SEM	P
	K	Z25		
Control milking – 7 day				
Number of animals	33	33		
Milk yield (kg)	32.0	31.6	0.61	0.89
Content in milk				
solids (%)	12.28	12.34	0.08	0.70
protein (%)	3.30	3.28	0.03	0.72
fat (%)	3.46	3.55	0.07	0.52
lactose (%)	4.90	4.87	0.02	0.42
urea (mg/L)	213	225	5.45	0.28
somatic cells (thous./mL)	168	188	28.44	0.72
Control milking – 30 day				
Number of animals	33	33		
Milk yield (kg)	31.2	30.2	0.55	0.36
Content in milk				
solids (%)	12.18	12.22	0.10	0.86
protein (%)	3.34	3.30	0.04	0.59
fat (%)	3.35	3.43	0.07	0.57
lactose (%)	4.88	4.86	0.02	0.50
urea (mg/L)	217	228	4.17	0.21
somatic cells (thous./mL)	106	163	25.41	0.27
Control milking – 60 day				
Number of animals	33	33		
Milk yield (kg)	31.6	31.2	0.62	0.80
Content in milk				
solids (%)	12.43	12.23	0.10	0.31
protein (%)	3.46	3.44	0.03	0.73
fat (%)	3.41	3.29	0.08	0.44
lactose (%)	4.91	4.86	0.01	0.07
urea (mg/L)	269	273	5.73	0.71
somatic cells (thous./mL)	129	183	23.0	0.25
Control milking – 90 day				
Number of animals	33	32		
Milk yield (kg)	31.1	31.2	0.71	0.97
Content in milk				
solids (%)	12.12	12.15	0.11	0.86
protein (%)	3.46	3.44	0.03	0.74
fat (%)	3.19	3.25	0.08	0.72
lactose (%)	4.93	4.90	0.02	0.42
urea (mg/l)	208	223	4.90	0.13
somatic cells (thous./mL)	149	144	21.74	0.90

Results

The chemical composition of the experimental feedstuffs is shown in Table 1, and the composition and nutritive value of the concentrates are shown in Tables 2 and 3 for study I, and in Tables 8 and 9 for study II. The PMRs were characterized by a similar protein content and nutritional value (nBO protein, net energy MJ NEL). It can be concluded that, with the same conditions of maintenance of all groups, the experimental factor was the feeding of concentrate containing 25 or 40% rye hybrid.

Table 7. The fatty acid profile of milk fat (% of FA) in study I

Fatty acids	Group		SEM	P
	K	Z25		
SFA (sum)	73.05	74.72	0.41	0.27
C14:0	14.28	14.36	0.16	0.75
C16:0	36.66	37.73	0.41	0.57
C18:0	5.25	4.65	0.23	0.11
MUFA (sum)	24.17	22.74	0.67	0.16
PUFA (sum)	2.73	2.49	0.11	0.14
C18:1 *n-7*	0.55	0.51	0.57	0.30
C18:1 *n-9*	17.80 a	15.97 b	0.07	0.04
C18:2	2.15	1.99	0.08	0.20
C18:3 *n-6*	0.05	0.04	0.01	0.30
C18:3 *n-3*	0.23	0.21	0.01	0.21
PUFA *n-6*	2.20	2.04	0.08	0.18
PUFA *n-3*	0.23	0.21	0.01	0.21
PUFA *n-6/n-3*	9.54	9.48	0.22	0.85
CLA[1]	0.30	0.24	0.02	0.07

a, b – values in rows marked with different letters differ significantly ($P \leq 0.05$).
[1]Sum of CLA isomers.

There was no difference in concentrate intake from the feeding station, in both study I and II. However, it should be noted that the animals from the experimental groups have eaten slightly more concentrate administered in the feed stations, in both study I and II (2.6% and 1.7%, respectively) (Tables 4 and 10). The feed intakes indicate that including rye in concentrate for dairy cows did not cause a significant change in the feed intake, and thus did not reduce the palatability of the concentrate.

The body weight and BCS of the cows in study I did not change during the study (Table 5). In study II, the animals gained an average of about 5% of body weight during the study in accordance with the phase of lactation and the physiological condition of the cows (Table 11). In both studies, the BCS of cows throughout the entire experiment was about 3 BCS points. Maintenance of optimal BCS and body weight of cows during lactation is a crucial factor for the "healthy" transition into the dry period, in which there is no time to gain or lose extra pounds. No effect of the concentrate containing two levels of hybrid rye on the weight and body condition of the cows was observed. In study I, the average daily milk yield for the entire experiment was about 32 kg/day in both study groups, K and Z25 (Table 6). Cows fed hybrid rye had a slightly lower daily yield in particular periods of lactation, but these differences were not statistically significant. Also, the persistence of lactation was similar in all groups of study I (Table 6). Cows fed hybrid rye at the level of 25% of the concentrate produced milk with a slightly higher content of fat, urea and somatic cells than the control cows.

Table 8. The composition and nutritive value of concentrate used in study II

Feed	Share in concentrate (%)		
	concentrate B in PMR	concentrate from feeding station K	concentrate from feeding station Z 40
Wheat, ground	20	89.7	-
Corn, ground	20	-	-
Rye, ground	-	-	79.2
Triticale, ground	15	-	-
Wheat bran	7.5	-	-
Rapeseed meal	15	-	10.5
Soybean meal	15	-	-
Limestone	1.5	1.3	1.3
Monocalcium phosphate	1	1	1
BergaFat	1	1	1
Premix*	4	4	4
Molasses	-	3	3
Sum	100	100	100
	Nutritive value (in 1 kg DM)		
MJ NEL/kg DM	6.8	7.2	7.0
nBO (g)	160	138.8	138.6
Total protein (g)	189.4	112.21	112.76

*Premix Kuh Gold Mineral (Sano), in 1 kg: P – 70 g, Ca – 140 g, Mg – 35 g, Na – 90 g, Cu – 1,000 mg, Zn – 12,000 mg, Mn – 4,000 mg, Vit. A – 1,000,000 UI, Vit. E – 5,000 mg.

Table 9. The composition and nutritive value of the PMR used in study II

Feeds	Group K and Z 25	
	PMR (kg)	PMR (%)
Corn silage	24	56
Alfalfa silage	8	19
GPS barley	5	12
Meadow hay	1	2
Concentrate B	5	11
	Nutritive value (in 1 kg of dry matter)	
Net energy NEL (MJ)	6.44	
Total protein (g)	130.5	
nBO (g)	143.9	

Table 10. Average daily feed intake by cows in study II

Study period (days)	Item	Group	
		K	Z40
1–100	complete ration – PMR (kg)	43.0	43.0
	concentrate from feeding station (kg)	4.02	4.09
	dry matter – DM (kg/day)	21.1	21.2
	net energy NEL (MJ/day)	139.1	139.5
	total protein (g/day)	3,172.1	3,183.2

Table 11. Body weight and BCS of the cows in study II

Item	Group	
	K	Z40
Body weight at the beginning of the experiment (kg)	515	507
Condition of the body at the beginning of the experiment (BCS, pts.)	3.0	2.9
Body weight at the end of the experiment (kg)	534	533
Condition of the body at the end of the experiment (BCS, pts.)	3.3	3.3

Table 12. Yield and chemical composition of milk in study II

Item	Group		SEM	P
	K	Z40		
Control milking – 7 day				
Number of animals	28	28		
Milk yield (kg)	32.16	31.63	0.88	0.77
Content in milk				
solids (%)	11.94	11.71	0.12	0.34
protein (%)	3.06	3.08	0.03	0.76
fat (%)	3.36	3.03	0.12	0.18
lactose (%)	4.96	5.07	0.03	0.05
urea (mg/L)	224	234	6.15	0.97
somatic cells (thous./mL)	202	192	44.27	0.91
Control milking – 30 day				
Number of animals	28	28		
Milk yield (kg)	35.74	35.04	0.64	0.59
Content in milk				
solids (%)	11.43	11.11	0.09	0.16
protein (%)	3.07	3.06	0.03	0.85
fat (%)	2.85	2.60	0.07	0.10
lactose (%)	4.99	5.01	0.07	0.60
urea (mg/L)	137	134	3.85	0.73
somatic cells (thous./mL)	492	137	90.61	0.06
Control milking – 60 day				
Number of animals	28	28		
Milk yield (kg)	35.73	34.77	0.67	0.49
Content in milk				
solids (%)	11.35	11.21	0.10	0.47
protein (%)	3.15	3.11	0.03	0.46
fat (%)	2.71	2.59	0.08	0.47
lactose (%)	4.94	4.99	0.02	0.10
urea (mg/L)	163	168	6.15	0.70
somatic cells (thous./mL)	349	200	67.58	0.20

However, there were no significant differences between the control and experimental groups in the chemical composition of the milk. The level of urea in the milk (Table 6): 213.36 mg/dl *vs*. 225.18 mg/dl, respectively, for the groups, was within the limits of standards (Carlsson et al., 1995)**,** which may indicate that the rations fed were properly balanced in terms of energy and protein content. The level of urea in milk is the parameter describing the correctness of the balance of the feeding and should be within the range of 150–300 mg/l at a milk protein content of 3.2–3.6% (Borkowska et al., 2006). No statistically significant differences between the control and experimental groups in the yield and composition of milk (Table 12) were observed in study II. However, animals from the group Z40, which were fed 40% of hybrid rye in the concentrate produced about 2.7% less milk than the control group. Milk from cows from the experimental group in study II contained less fat and urea and somatic cells, but these differences were not statistically significant. The content of urea were within the physiological norms for this component.

Table 13. The fatty acid profile of milk fat (% of total FA) in study II

Fatty acids	Group		SEM	P
	K	Z40		
SFA (sum)	74.43	73.78	0.01	0.59
C14:0	14.42	14.59	0.15	0.45
C16:0	37.32	36.94	0.18	0.36
C18:0	5.47 A	4.78 B	0.12	0.00
MUFA (sum)	23.75	22.69	0.47	0.16
PUFA (sum)	2.79	2.61	0.05	0.20
C18:1 *n-7*	1.55	1.55	0.06	0.30
C18:1 *n-9*	16.47 b	17.01 a	0.42	0.04
C18:2	2.25	2.09	0.04	0.20
C18:3 *n-6*	0.05	0.05	0.01	0.64
C18:3 *n-3*	0.23	0.23	0.01	0.88
PUFA *n-6*	2.30	2.13	0.04	0.20
PUFA *n-3*	0.23	0.23	0.01	0.88
PUFA *n-6/n-3*	10.03	9.39	0.32	0.85
CLA[1]	0.26	0.24	0.01	0.59

a, b – mean values in rows marked with different letters differ significantly at $P \leq 0.05$; A, B – $P \leq 0.01$.
[1]CLA given as a sum of isomers.

The results for the fatty acid profile of milk samples confirmed that the type of ration caused the changes in the content of particular fatty acids in milk fat. However, the differences obtained in study I were not statistically significant (Table 7). Milk from the group of cows fed 25% hybrid rye in the concentrate contained a slightly higher amount of saturated fatty acids and a lower content of conjugated linoleic acid (CLA) compared to the control group.

A higher content of myristic (C14:0) and palmitic (C16:0) acids can be associated with a higher content of these fatty acids in rye when compared to other cereals. Significant differences were noted in the content of oleic acid (C18:1), which was significantly less ($P<0.05$) in the milk of the cows from the experimental group (Table 13). It should be noted that the content of other fatty acids which are considered as health promoting, linoleic (C18:2) and linolenic (C18:3) acids, was nearly identical in both groups. This fact, with no statistically significant differences, may indicate that the addition of hybrid rye at 25% of the concentrate did not decrease the health value of the milk.

In turn, in study II the milk of cows from the experimental group with a 40% share of hybrid rye in the concentrate contained slightly less saturated fatty acids and, highly significantly ($P<0.01$) less of stearic acid C18:0 but significantly more of C18:1 *n-9* acid than the milk from the control cows, which may indicate better health benefits as compared to the control milk. In both studies I and II there were no statistically significant differences between the treated and control groups in the content of acids of the MUFA and PUFA family. Milk from cows from the experimental groups with a slightly lower level of *n-6* PUFA fatty acids and identical *n-3* PUFA acids was characterized by a lower *n-6/n-3* ratio, which is preferable from a consumer perspective. These differences were, however, not statistically significant.

Discussion

Rye (*Secale* L.) is mainly grown for grain, especially in Europe and North America in areas where the climate and soil are unfavourable for other cereals, especially for winter wheat (Fuller, 2004). Although world production of rye is less than 1% of all cereals (FAO, 2012), this crop remains an important grain for bread production in northern and eastern Europe as more than 30% of the flour used in bread production. In 2011 the main producers of rye were Russia, Germany and Poland, which accounted for 64% of the total world production (12.9 million tonnes) (FAO, 2013). Polish sandy soils used for the production of rye are competitive when compared to the cost of production of wheat.

Over 40% of the production of rye in Poland is used for animal feeding, mainly pigs and cattle. Rye grain contains about 10% crude protein of DM and a low level compared to wheat, barley, oats and triticale (Micek, 2008). It has a low crude fiber content (about 2%) and a high starch content (approximately 62% of dry matter), which was confirmed in this study. Rye as a potentially valuable feed grain has a high energetic value and low fiber content; however it is not widely used in the feeding of poultry and young pigs. The main limits in the feeding of poultry and pigs is the content of the high amounts of soluble non-starch polysaccharides – arabinoxylans – which increase the viscosity of gastric contents, thus reducing the absorption and bioavailability of nutrients in pigs and poultry (Maner, 1987).

In relation to ruminants rye has a high metabolizable energy value of 13.1 MJ/kg DM (Sauvant et al., 2004), similar to corn, wheat, barley and triticale (Denek and Deniz, 2004), but higher than in oats (Südekum et al., 1994). However, the value of rye protein is quite low, which should be taken into account when balancing rations for ruminants (DLG, 1997; Micek, 2008). In addition, there is a risk of the appearance of ergot alkaloids which can have an impact on reducing the use of rye in the nutrition of ruminants (Denek and Deniz, 2004). Grains of rye used in the fattening of cattle and dairy cows' feeding provides similar performances compared to barley (Sharma et al., 1983; Brzóska et al., 1999).

Improvement of production results was obtained by mechanical treatment or by chemical factors treatment as alkalizing whole seed grains with NaOH (35 g/kg of grains). Both of these treatments improve the digestibility of nutrients (Sharma et al., 1981). However, the high content of rapidly degradable starch (almost 60% DM) should be taken into account in the preparation of rations, especially for high yielding cows, which should follow nutritional recommendations taking into account the size and rate of degradation of starch (Nocek and Tamminga, 1991; Micek and Kowalski, 2010; Lechartier and Peyraud, 2011; Hellwing et al., 2013). Other important factors having a significant impact on the environment of the rumen and its ability to maintain a proper pH are the length of the feed particles, the level of NDF and the electrolyte balance (Zebeli et al., 2008).

In order to objectively examine the impact of the use of rye in the feeding of dairy cows, the present experiments were carried out on high yielding cows in a PMR feeding system which is an effective method of reducing the negative impact of feeding large amounts of grain to dairy cows (Bargo et al., 2002). Feeding cows with concentrates containing in its composition 25 or 40% of the ground hybrid rye did not cause a decrease in DM intake compared to the control groups. It can be considered that the tastiness of rye is similar to wheat, as shown in this study, as well as in studies of other authors conducted on young bulls (Sharma et al., 1981), and dairy cows (Sharma et al., 1983; McQueen and Fillmore, 1991; Brzóska et al., 1999).

Our study, along with other authors' works (Sharma et al., 1981; Smith et al., 1994), showed that partial or total replacement of crushed barley or wheat by crushed rye in the concentrates for cows did not reduce the feed intake, milk yield, content of chemical components of the milk. Kirilov et al. (1994), who fed cows with rations that contained concentrates containing 20%, 40% and 50% rye meal, found no reduction in milk yield compared to the same ration in which the basic ingredient was crushed barley. In turn, Kraszewski and Kozlowski (2000), using a concentrate containing 50% of the rye variety *Motto*, obtained a statistically significant deterioration in the milk yield and the quality of the milk fat compared to a control group. These authors, however, pointed out that rye contains the most antinutritional substances. However, the content is highly variable, conditioned by genetic and environmental factors. In the present study we observed no significant decrease in the productivity of cows, which produced an average of 31 kg of milk per day in study I where 25% rye in the concentrate content was used, and 35 kg/day in study II where 40% of rye fed was used. This fact can be explained by an average content of antinutritional substances including alkylresorcinols in the rye hybrid *Visello* used in the study, as compared to wheat (Boros, 2011). It should be emphasized that the milk obtained in study I and II in all groups meets the nutritional requirements of a superior class, wherein the tendency to a lower somatic cell count was observed in the milk of cows receiving 25% and 40% of rye in the concentrate.

It appears that the use of a large amount of rye in the feeding of high yielding cows is characterized by a rapid and large degradation of starch in the rumen (Offner et al., 2003; Micek and Kowalski, 2010), which results in an accumulation of fermentation products, mainly VFA and lactic acid, which leads to a lowering of the pH of the rumen. This can cause acidosis and an increase of amylolytic microflora in the rumen, thereby reducing the share of cellulolytic microflora (Sauvant et al., 1994). A consequence of the use of large amounts of feedstuffs rich in rapidly digestible starch leads to a reduction of fiber digestibility and a reduction in the use of energy from the rations (Ørskov and Ryle, 1998), which is usually manifested by reduced levels of fat in milk (van Knegsel et al., 2007).

There is little scientific evidence that the feeding of dairy cows with rye leads to an increase of saturated fatty acid contents in milk and a deterioration of the nutritional and physico-chemical properties of butter especially its colour, taste and consistency (Kraszewski and Kozłowski, 2000). Comprehensive studies conducted by Micek (2008) on the chemical composition of cereals cultivated in Poland, among others hybrid varieties of rye, showed the highest level of linoleic acid of *n-3* (5.01%) compared to wheat (3.15%), barley (3.97%) and oat (2.10%) grains. In addition, hybrid rye contains more C18:1 oleic acid as compared to other cereals. The results obtained in study II, with the use of 40% of the rye hybrid variety *Visello*, could cause significantly higher oleic acid content in the milk of the studied cows. Several studies carried out in humans confirm that C18:1, C18:2 and C18:3 acids increase blood flow through the coronary vessels, thus preventing atherosclerosis, heart attacks and strokes. Moreover, they participate in the regulation of cardiovascular activities – vascular blood pressure, gastrointestinal and reproductive organs, and have an anti-cancerogenic action (Miller et al., 2000; Parodi, 2005). In this study there was a significant decrease in the levels of certain saturated fatty acids, including stearic acid. There are opinions that saturated fatty acids effect an increase in the total cholesterol level in the blood which would predispose a presence of many diseases, especially cardiovascular (Miller et al., 2000).

In summary, it can be stated that the addition of hybrid rye to the concentrate for dairy cattle did not have a significant impact on DM intake of the ration and concentrate mixture from a feed station, which means that the applied addition of approximately 25% and 40% of hybrid rye to mixtures for dairy cows did not reduce the animals' appetite. Introduction of 25% or 40% of the rye hybrid variety *Visello* to the concentrate did not reduce the milk yield of the cows during the first 100 days of lactation. Any differences in the chemical composition of the milk were not observed. Cows fed the rye maintained a proper weight and body condition during the first 100 days of lactation. The addition of the rye hybrid to concentrates in the amount of 25% has no significant effect on the fatty acid profile of milk, and in the amount of 40% may even improve the fatty acid profile by lowering the C18:0 and increasing the C18:1 *n-9* content.

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Received: 3 VI 2014
Accepted: 14 V 2015