PERFORMANCE AND COMPOSITION OF FATTY ACIDS IN MILK OF COWS FED DIETS WITH HIGH MOISTURE CORN OR CORN COB MIX

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Abstract. The aim of the present experiment was to compare production effects and the content of fatty acids in milk and metabolites in blood of cows in the first 100 days of lactation when cows were fed rations with high-moisture corn (HMC) or corn cob mix (CCM), both with 20% content of DM in TMR. The research was conducted on 36 HF multiparous cows divided into two feeding groups (HMC, CCM). Two periods of lactation were distinguished: to the 30th day and 31-100th days of lactation. DMI in both groups was similar and amounted to 23.85 kg. In the preliminary lactation phase (to the 30th day), a higher milk production (by 5.65 kg) with lower protein content in milk ($p \leq 0.01$), lower SFA content (particularly C_{12}, C_{14}, C_{16}) and higher MUFA content, including oleic acid ($p \leq 0.01$) was observed in cows fed CCM. Moreover, for HMC diet the contents of urea in milk and BUN were lower ($p \leq 0.01$) while the use of ration nitrogen and glucose concentration in blood were higher ($p \leq 0.05$ and 0.01 respectively) in comparison to the CCM diet. The lactation phase determined the FA profile in milk, TG level and total cholesterol in blood. There was no interaction observed between the diet type or lactation phase and ECM efficiency, fat content in milk, daily efficiency of fat and protein as well as the content of total protein in blood serum or the activity of AST and ALT enzymes. The use of simplified corn harvest technology in the form of corn cobs (CCM) may be the alternative to traditional harvest with a harvester which lowers the feeding costs of high-yielding dairy cows.
Keywords: corn cob mix (CCM), high moisture corn (HCM), silage, milk, fatty acid, blood parameters.

EFEKTYVUMAS IR PIENO RIEBIŲJŲ RŪGŠČIŲ SUDĖTIS ŠERIANT KARVES DIDELIO DRĖGNUMO KUKURŪZŲ ARBA KUKURŪZŲ BURBUOLIŲ MIŠINIU

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Santrauka. Tyrimo tikslas buvo palyginti poveikį gamybai ir pieno riebiųjų rūgščių bei karvių kraujo metabolitų sudėčiai per pirmas 100-ąsias laktacijos dienas, kai karvės buvo šeriamos racionais didelio drėgnumo grūdų (HMC) arba kombinuotojo pašaro (CCM), kurių sudėtyje buvo 20 proc. sausosios medžiagos (angl. DM), mišiniais (TMR). Tyrimas atliktas su 36-iomis didelio pieningumo (angl. HF) karvėmis, suskirstytomis į dvi grupes (šeriamos didelio drėgnumo grūdais ir kombinuotuoju pašaru). Išskirti du laktacijos laikotarpiai: iki 30-osios dienos ir nuo 31-osios iki 100-osios laktacijos dienos. Abiejų grupių karvės sausąsias medžiagas pasisavino (angl. DMI) panašiai ir siekė 23,85 kg. Pirmoje laktacijos fazėje kombinuotuoju pašaru šertoms karvėms (iki 30-osios dienos) buvo padidėjęs pieningumas (5,65 kg), piene buvo mažiau baltymų ($p \leq 0{,}01$), mažiau sočiųjų riebalų rūgščių (angl. SFA), ypač C_{12}, C_{14}, C_{16}, bet daugiau mononesočiųjų riebalų rūgščių (angl. MUFA), įskaitant ir oleino rūgštį ($p \leq 0{,}01$). Karvių, šertų didelio drėgnumo grūdais, šlapalo kiekis piene ir kraujo šlapalo azoto (angl. BUN) reikšmė buvo mažesni ($p \leq 0{,}01$), nors, taikant šį racioną, azoto ir gliukozės koncentracija kraujyje buvo didesnė (atitinkamai $p \leq 0{,}05$ ir 0,01) palyginti su duomenimis, gautais šeriant karves kombinuotuoju pašaru. Nustatytas riebiųjų rūgščių (angl. FA) profilis piene, triglicerido (angl. TG) lygis ir bendras kiekis kraujyje cholesterolio, kuris neturėjo sąveikos tarp raciono tipo bei laktacijos fazės ir energetiškai koreguoto pieno (angl. ECM) produktyvumo, riebalų kiekio piene, riebalų ir baltymų produktyvumo, kaip ir bendrojo baltymų kiekio kraujo serume ar aspartato aminotransferazės (angl. AST) bei alanino aminotransferazės (angl. ALT) enzimų aktyvumo. Supaprastintos grūdų derliaus nuėmimo technologijos kombinuotiesiems pašarams ruošti (angl. CCM) gali būti alternatyva tradiciniam derliaus nuėmimui, nes didelio pieningumo karvėms sumažina šėrimo išlaidas.
Raktažodžiai: kombinuotasis pašaras, didelio drėgnumo grūdai, silosas, pienas, riebiosios rūgštys, kraujo rodikliai.

Introduction. Cows in the first phase of lactation often have a negative energy balance. The main feeding goal in this period is maximizing the energy intake. This factor has a significant impact on the peak milk yield and lactation persistency (Oba and Allen, 2003). A common way to increase the energy intake is to increase its concentration in the ration by feeding with a bigger amount of cereal grains. Feeding rations with a high content of wheat starch increases the feeding costs and increases the risk of subclinical rumen acidosis (Goff, 2006). High moisture corn can be a competitive source of starch in relation to traditional cereals (Moura et al., 2007). Moreover, high corn yields and energy value have impact on a low production cost of energy unit for this feed (Knowlton et al., 1998, Fernandez et al., 2004, Jensen et al., 2005). A high concentration of metabolic energy in the corn grain is associated with a higher content of starch and fat as well as small sizes of starch granules. Rumen digestibility of corn grain is varied and depends on the degree of shredding and the method of corn preservation (Ying et al. 1998, Yu et al.1998). A high content of high moisture corn grain in the form of silage determines the energy intake and rumen degradability of rations in cows (Allen, 2000).

High water content in corn grain harvested in Poland excludes its drying so a significant cost in the high moisture grain production is still its harvest, chop and storage. In production of silage from whole corn plants, chaff cutters equipped with grain processor which also can be equipeped with adapters for picking cobs are commonly used. This equipment facilitates harvest of corn cobs in the form of chaff which is then crushed (corn grain with cores). When compared with the traditional grain harvest, this technology shortens the harvest time in difficult weather conditions and lowers the costs. As a result of harvest by this technology a new type of feed is produced which differs from the grain in respect to its content of starch and structural carbohydrates as well as the physical structure.

The impact of using feeds from corn with a varied carbohydrate composition, physical structure and rumen digestibility on the productivity and milk composition and milk fatty acids composition in cows can be different**.** Currently, greater attention is paid to the fat content in forages which are the basis in feeding dairy cows (Vanhatalo et al., 2007; Steinshamn and Thuen, 2008; Bernardini et al., 2010). Forages not only provide substrates for cellulolytic bacteria, but also are the source of fatty acids, including unsaturated fatty acids (Dewhurst et al., 2006).

Many studies deal with the use of HMC in the diet of dairy cows and the effect of feed on milk composition but there are few studies concerning the effects of CCM (Knowlton et al., 1998, Oba and Allen, 2003). Therefore, the aim of the experiment was to compare production effects and the composition of fatty acids in the milk and metabolites in blood of cows in the first 100 days of lactation fed rations containing high moisture corn grain or shredded corn cobs.

Materials and methods. The research was conducted in a facility specializing in milk production in the north-east Poland. In research a mid-early hybrid PR39H32, PIONEER Co. (FAO 230) was used which was served in the form of high moisture corn grain (HMC) or Corn Cob Mix (CCM). Experimental feeds were harvested in the same period (15-18 October) at full ripeness, with DM content of 606.2 g/kg. HMC was crushed in a roll mill crusher (ROMILL). Cobs for CCM production were harvested and shredded with flywheel chaff cutter (John Deere 7050) equipped with adapter for picking cobs and grain crusher. The theoretical cutting length of the cutting unit was 5 mm (56 knives on the cutting drum). Both feeds were silaged and stored in a silage bag (AG BAG Corp.). After 85 days of storage, samples of HMC and CCM were collected and their chemical composition was analyzed (Table 1).

Table 1. **Chemical composition of experimental feed**

Item	HMC	CCM	SE
DM g/kg	581.2	527.4	0.3
pH	3.49	3.66	0.1
In g/kg DM			
OM	975.1	973.4	0.2
CP	92.9	103.4	0.3
Ether extract	39.4	36.8	0.2
Starch	662.0	532.0	1.4
NDF	94.4	252.5	0.7
ADF	29.0	122.2	0.2
Lactic acid	38.2	41.3	0.3
VFA	16.7	21.2	0.2
Ethanol	2.5	3.2	0.1
Mean particle size, μm	1472	6765	72.9

Animals and feeding. The feeding research was conducted on 36 HF multiparous cows with body weight of 670 ±40 kg; milk yield 34.5±5,9 kg/d; milk fat 36.1±4,7 g/kg; milk protein 32.8±2,1 g/kg divided by the analogy method into two feeding groups (HMC, CCM) taking into account the order of lactation (the 2nd and 3rd lactation) and the production level in the previous lactation. The cows were observed from the 1^{st} to 100^{th} day of lactation, distinguishing two periods: to the 30^{th} day of lactation (4 weeks after calving) and from the 31^{st} to 100^{th} day of lactation. The animals were kept separately in a tie-stall system with double spaces between them in order to prevent feed intake from neighboring stands. TMR with experimental feeds (HMC, CCM) were prepared once a day on a feed carrier with horizontal mixing system on the basis of formula specified in Table 2, assuming the 20 % content of HMC or CCM in DM of TMR. The amounts of fed TMR and feed refusal were recorded daily.

Sampling and chemical analysis

Samples of all components and TMR rations were chemically analyzed before the research and three times during the feeding experiment. The content of DM in TMR and feed refusals were monitored weekly. The basic chemical composition was determined by standard methods (AOAC, 2005), NDF content, ADF with the method of Van Soesta et al. (1991) with the use of ANKOM 220 (bulky feeds) or Fibertec 2010 from Foss Tecator (concentrate feeds). In silages pH was determined with a pH meter HI 8314, the content of acids – acetic, butyric, propanoic acid – by gas chromatography with apparatus (type 6890) supplied with flame ionization detector (FID), lactic acid and ethanol by HPLC method. The starch content was marked with enzymatic method presented by Jensen et al. (2005). Further, the shredding of HMC was evaluated with Retsch sieves set while CCM with Pensylwania State University separator. Experimental diets were balanced in accordance with the DLG system (1997).

Table 2. **Ingredients and nutrient composition of experimental diets** (% of dietary DM)

Item	HMC	CCM
Diet ingredients		
Maize silage	31.2	31.2
Grass silage	14.2	14.2
Barley straw	3.8	3.8
HMC	20.0	-
CCM	-	20.0
Barley ground	7.8	7.8
Soybean meal 46% CP	7.8	7.8
Rapeseed meal "00"	11.6	11.6
Limestone	0.88	0.88
Dicalcium phosphate	0.51	0.51
Sodium bicarbonate	0.75	0.75
Urea	0.43	0.43
Vitamins and trace minerals[1]	1.03	1.03
Nutrient composition		
DM	46.53	45.77
OM	94.49	94.69
CP	17.59	17.80
Ether extract	3.66	3.11
Starch	27.05	24.44
NDF	28.82	31.30
ADF	17.44	19.26
NFC[2]	44.42	42.48
NEL MJ	6.79	6.67

[1]Contained 1000mg/kg of Cu 35mg/kg of Se 4200 mg/kg of Zn 440,000 IU of vitamin A/kg, 130,000 IU of vitamin D/kg, and 2600 IU of vitamin E/kg

[2]Nonfiber carbohydrates = 100- (% NDF + % CP + % ether extract + % ash)

The milk yield in cows was recorded daily, in milking parlours, twice a day and presented in kg of milk standardized depending on the energy value ECM (Huhtanen et al. 2003). ECM (kg) = milk (kg)x[38,3x fat(g/kg) + 24,2 protein (g/kg) + 783,2]/3140.

The content of fat, protein and urea were determined in milk samples collected in trial milking with Milko-Scan 4000 infrared analyzer (Fossomatic, Denmark).

The content of fatty acids (FA) was determined in TMR (Table 3) and in milk samples collected on the 28th and 90th day of lactation. Fatty acids were separated by gas chromatography (VARIAN CP 3800 chromatograph, flame-ionization detector FID, capillary column 50 m x 0.25 mm x 0.25 µm film, detector temperature 250ºC, column temperature 50ºC → 200ºC, sample dosing – split/50:1, carrier gas – helium).

Table 3. **Fatty acids composition of experimental diets** (g/100g fatty acids)

Fatty acid	HMC	CCM
$C_{12:0}$	0.18	0.31
$C_{14:0}$	0.40	0.89
$C_{16:0}$	14.35	18.52
$C_{18:0}$	2.60	3.82
$C_{18:1}$	19.67	20.61
$C_{18:2}$	36.66	38.40
$C_{18:3}$	19.43	14.96
Other	6.71	2.49
Saturated fatty acids SFA	20.21	23.62
Monounsaturated fatty acids MUFA	22.59	22.14
Polyunsaturated fatty acids PUFA	57.20	54.24
Total n – 3	19.63	15.12
Total n – 6	36.88	38.68
n – 6/n – 3	1.88	2.56

Feed conversion of cows was estimated on the basis of produced ECM milk per intake of kg DM ration, and the efficiency of milk protein synthesis was established as a ratio of mean daily milk nitrogen efficiency and mean daily intake of nitrogen in the ration.

Blood samples were taken from the jugular vein prior to the morning feeding between 28th and 90th day of lactation. Serum was separated by centrifugation at 2000 x g for 15 min and stored at – 20ºC until analyzed. Serum samples were analyzed for glucose, triglycerides (TG), total cholesterol, total protein and blood urea nitrogen (BUN) level as well as for alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities using the tests of Pointe Scientific Methods (Catalogue no. G7521; T7532-5; C7510; T7528; B7552; A7526; A7561) and the Epoll 200 spectrophotometer.

The research results were statistically verified with the method of two-way analysis of variance presented by the following model:

$$X_{ijk}= \mu + a_i + b_i + (ab)_{ij} + e_{ijk}$$

where:

μ – is the mean;

a_i – effect i–of that factor;

b_i – effect j–of that factor;

$(ab)_{ij}$ – interaction of factors in the subgroup (i ,j);

e_{ijk} – effect of factors specific for k – that element of subgroup (i, j).

The significance of differences between the means and interactions was verified with Duncan test. Factors analyzed included types of feeds from corn (HMC; CCM) and lactation period (0-30; 31-100). Statistical calculations were conducted according to Statistica 9.0.

The research results. The daily intake of DM in both groups was similar and on average amounted to 23.85 kg

(Table 4). The daily milk yield of cows fed CCM in the preliminary phase of lactation (to 30th day) was significantly higher (p≤0.05) in comparison to the yield in further phases of lactation and cows fed HMC. In HMC diet, a higher milk yield (p≤0.05) was observed in cows in a further phase of lactation. The type of feed from corn, particularly to the 30th day of lactation, had a significant impact (p≤0.01) on the protein content in milk (Table 4). The impact of diet type or phase of lactation on ECM efficiency, fat content in milk and daily fat and protein efficiency was not observed. The urea content in milk of cows fed CCM was higher (p≤0.01), irrespectively of the lactation phase. Feed conversion, estimated with the amount of ECM milk produced from 1 kg of DM ration was similar, though the highest efficiency of DM conversion was observed in cows fed CCM in the first phase of lactation (insignificant differences).

Table 4. **Yields of milk and milk components of cows fed diets HMC and CCM**

Item	HMC		CCM		SE	P		
	Days of lactation					C[1]	DL[2]	CxDL[3]
	0-30	31-100	0-30	31-100				
Dry matter intake, kg/d	23.20	24.30	24.10	23.80	0.34			
Milk yield, kg/d	35.23[a]	38.28[ab]	40.88[b]	34.69[a]	1.36			x
ECM, kg/d	34.35	35.87	38.35	33.34	1.19			
Milk fat, g/kg	38.46	35.96	38.44	38.27	0.09			
Milk fat, kg/d	1.34	1.37	1.55	1.32	0.05			
Milk protein, g/kg	33.81[A]	32.80[AB]	28.70[B]	32.52[A]	0.06			xx
Milk protein, kg/d	1.19	1.25	1.18	1.12	0.04			
Urea, mg/l	138.3	134.6	258.8	284.2	8.02	xx		
ECM/DM, kg/kg	1.48	1.49	1.58	1.41	0.02			
N milk/ N intake, %	28.60	28.30	26.90	26.20	0.03	x		

[1]C - effect of corn conservation method; [2]DL - effect days of lactation; [3]C x DL - interaction of corn conservation method and days of lactation; A,B P ≤ 0,01 a,b P ≤ 0.05

The content of fatty acids in milk is presented in Table 5. In CCM milk, the lowest content (p≤0.01) of SFA and the highest (p≤0.01) of MUFA was noted to the 30th day of lactation. The milk from that period had a significantly lower content of lauric, myristic and palmitic acids whereas the amount of oleic and arachidonic acids was significantly higher in comparison with the milk from cows fed HMC. In HMC milk there was also a higher content (p≤0.05) of CLA and linolenic acid (p≤0.01). With the progress of lactation, irrespectively of the diet type, the profile of fatty acids in milk was changing. There was a significant SFA increase (p≤0.01), including medium chain fatty acids (MUFA) (C_8-C_{16}), whereas the amount of stearic acid (p≤0.05) and oleic acid was lower (p≤0.01). No impact of the lactation phase on the level of functional acids, such as: butyric acid, linoleic acid, CLA, linolenic acid, arachidonic and eicosapentaenoic acid, was observed. Irrespective of the lactation period, milk from cows fed HMC had a significantly higher content of n-3 PUFA.

The analysis of biochemical indices in blood serum revealed that the levels of glucose and BUN were varied depending on the type of fed diet (Table 6). A higher concentration of glucose (p≤0.01) was observed in the serum of cows fed HMC ration. In the same group, the BUN level was lower (p≤0.01) in comparison to the results of cows fed CCM ration. Moreover, the concentration of triglycerides (TG) and total cholesterol in blood serum with the progress of lactation increased significantly in both groups (p≤0.01). The impact of the lactation phase and diet type on the content of total protein in the serum and the activity of enzymes AST and ALT was not observed.

Discussion. The type of feed produced from corn (HMC, CCM) and the lactation phase of cows did not have a significant impact on the DMI. It is worth stressing that the intake level in cows fed HMC ration, which is characterized by a lower physical fill (higher content of starch and lower NDF), was insignificantly lower in the first 30 days of lactation in relation to the CCM ration. NDF of bulky feeds is the main factor reducing the intake by physical fill in the rumen (Allen, 2000). Lower DMI in cows fed HMC ration in the first phase could be caused by the production of propionates in the rumen. Propionates have greater hypophagic effects than acetate (Sheperd and Combs, 1998). However, in further measuring period, the intake in the group fed grain was insignificantly higher (insignificant differences) in comparison to cows fed ration with corn cobs. Similarly to the research by Knowlton et al. (1998), various treatments on corn grain did not impact DMI, whereas the corn form (silaged or dry grain) in low and high-starch rations differentiated the milk yield of cows and fat and protein content in milk (Oba and Allen, 2003). In our research, we observed a significant interaction between the daily yield of cows and protein content in milk (Table 4). In the preliminary phase of lactation (to the 30th day), the milk yield of cows fed HMC ration (higher starch content) in comparison to CCM was lower by 16 % (35.23 vs. 40.88 kg; p≤0.05), while the protein content in milk was higher (p≤0.01) by nearly 17% (3.38 vs. 2.87%). According to Theurer et al. (1999), a higher degradability of starch in the rumen, with a balanced energy supply, has a positive impact on the scope of microbiological protein synthesis, which results from a higher protein synthesis in the mammary gland and the use of N from the feeding ration. This is confirmed by the results of the present research as cows fed HMC ration had a lower content of blood urea nitrogen (BUN) and urea in milk in comparison to cows fed CCM ration. Moreover, in HMC diet, the use of ration protein for milk protein synthesis (N milk/N intake) in relation to CCM diet was higher and mean values were 28.45 and 26.55% ($p \leq 0.05$) respectively. This was due to a higher glucose concentration in cows fed HMC ration (Table 6). It was proved that when cows were fed high-starch diets, the number of precursors available for gluconeogenesis was increased (Lemosquet et al., 2004) and there was an increase in glucose resorption from the digestive system (Zhao et al., 1998).

The levels of TG and total cholesterol in blood serum in both groups were similar and were determined by the lactation phase. A lower TG concentration in blood serum in the periparturient period is a common occurrence for cows (Pysera and Opałka, 2000; Darul and Kruczyńska, 2005) and points to the important role of lipids in colostrum and milk synthesis. According to Bronicki (2001), after parturition TG are quickly metabolized; their level is lower in serum and soon reaches back its previous level. This finds confirmation in the results of our research as the TG level with the progress of lactation was significantly increased. Alike, a systematic increase of cholesterol concentration in the blood serum of cows may positively attest to their fertility. Reproduction indices of cows are greatly determined by lipid and cholesterol concentration, which is essential for synthesis of gonadotropin hormones and progesterone (McNamara et al., 2003). Bronicki and Dembiński (1995) show that fatty acids provided in the ration, which are precursors of prostaglandines, stimulate the functioning of ovaries, which shortens and facilitates proper *puerperium* in cows.

Table 5. **Milk fatty acid composition** (g/100g of milk fat) **of cows fed diets of HMC and CCM**

Fatty acid	HMC		CCM		SE	P		
	Days of lactation					C[1]	DL[1]	INT[1]
	0-30	31-100	0-30	31-100				
$C_{4:0}$	3.08	2.92	3.00	2.69	0.08			
$C_{6:0}$	2.05	2.21	1.89	2.20	0.06		x	
$C_{8:0}$	1.42	1.52	1.17	1.56	0.06		xx	
$C_{10:0}$	3.58^{a}	3.84^{ab}	2.58^{b}	3.92^{a}	0.21	x	xx	x
$C_{10:1}$	0.41^{a}	0.46^{ab}	0.30^{b}	0.42^{a}	0.04	xx	xx	x
$C_{12:0}$	4.38^{a}	4.81^{ab}	2.43^{b}	4.80^{a}	0.32	x	xx	x
$C_{13:0}$	0.25^{a}	0.19^{ab}	0.08^{b}	0.20^{a}	0.03	x	x	x
$C_{14:0}$	11.71^{A}	13.10^{AB}	7.86^{B}	13.74^{A}	0.65	x	xx	xx
$C_{15:0}$	1.72^{a}	1.42^{ab}	0.76^{b}	1.48^{a}	0.17			x
$C_{16\ izo}$	0.13	0.18	0.28	0.34	0.03	xx		
$C_{16:0}$	29.68^{a}	32.11^{ab}	26.20^{b}	33.57^{a}	0.89		xx	x
$C_{17:0}$	0.68	0.53	0.81	0.56	0.03	x	xx	
$C_{17:1}$	0.50^{A}	0.43^{AB}	0.79^{B}	0.36^{A}	0.05		xx	xx
$C_{18:0}$	9.58	9.24	12.66	8.48	0.76		x	
$C_{18:1}c9$	22.9^{A}	19.51^{AB}	32.94^{B}	18.94^{A}	1.60	x	xx	xx
$C_{18:2}$	2.52	2.25	2.13	2.11	0.10			
CLAc9	0.57^{a}	0.45	0.38^{b}	0.44	0.03	x		x
$C_{18:3}$	0.66	0.66	0.27	0.25	0.04	xx		
$C_{20:0}$	0.12	0.11	0.13	0.13	0.01			
$C_{20:1}$	0.05	0.03	0.08	0.03	0.009		xx	
$C_{20:2}$	0.02	0.02	0.03	0.05	0.006			
$C_{20:4}$	0.16	0.15	0.22	0.22	0.01	xx		
$C_{20:5}$	0.05	0.04	0.04	0.04	0.004			
$C_{22:0}$	0.05	0,05	0,13	0,17	0,02	x		
Other [2]	3.72	3.77	3.22	3.30	0.07			
SFA	68.49^{A}	72.31^{AB}	59.81^{B}	73.96^{A}	1.60		xx	xx
MUFA	27.54^{A}	24.12^{AB}	37.12^{B}	22.92^{A}	1.59	x	xx	xx
PUFA	3.97	3.57	3.07	3.12	0.14	xx		
Total n-3	0.71	0.70	0.31	0.29	0.04	xx		
Total n-6	2.69	2.42	2.38	2.38	0.08			

[1] see Table 4; [2] $C_{12:1}$; C_{14izo}; $C_{14:1}$; $C_{16:1}$; A,B $P \leq 0,01$ a,b $P \leq 0,05$

Table 6. **Some metabolic indices in blood serum of cows fed diets of HMC and CCM**

Item	HMC		CCM		SE	P		
	Days of lactation					C[1]	DL[1]	INT[1]
	0-30	31-100	0-30	31-100				
Glucose, mmol/l	3.50	3.55	3.07	3.22	0.08	xx		
Triglycerides, mmol/l	0.10	0.14	0.12	0.15	0.007		xx	
Total cholesterol, mmol/l	3.08	4.73	3.04	4.71	0.16		xx	
BUN, mg/dl	10.6	12.4	14.8	14.1	0.54	xx		
Total protein, g/l	78.2	73.3	76.3	73.5	1.94			
AST, U/l	64.4	74.2	68.5	65.1	2.66			
ALT, U/l	29.8	31.8	30.0	31.4	1.34			

[1] see Table 4.

Despite a similar content of fatty acids in both diets (Table 3), the FA profile of milk fat was varied and determined by the feed type and lactation phase of cows (Table 5). In the preliminary lactation phase, a lower SFA content (particularly of C_{12}, C_{14}, and C16) in the milk of cows fed CCM was very beneficial as for its health value (Barłowska and Litwińczuk, 2009). However, HMC ration was a better source for CLA precursors. A 50% higher CLA content in milk in HMC diet than in CCM could result from desaturation of vaccenic acid in the mammary gland conditioned by a higher availability of linoleic acid from the ration, which is a common precursor of these two acids (Kay et al., 2004). Moreover, linolenic acid from HMC ration underwent a smaller ruminal biohydrogenation than from CCM as its concentration in milk was over 2 times higher, which determined a more beneficial relation of n-6/n-3 PUFA in the milk (Vanhatolo et al. 2007). The FA profile in cows fed CCM ration was significantly changing throughout lactation phases. With the beginning of lactation the general SFA content in milk increased by 23.7%, while the MUFA content was lowered by 38%. In HMC ration, these values were lower (by 5.6% and 12.4% respectively for SFA and MUFA).The observed changes in the FA profile are interesting as in our experiment no fat additives were used. The majority of previous research focused on the effects of supplementing feeding rations with various fat additives, including oilseeds and calcium soaps (Schroeder et al., 2004; Strusińska et al., 2006; Marchesini et al., 2009).

Conclusions. The type of feed produced from corn (HMC, CCM) and the lactation phase of cows did not have a significant impact on DMI, ECM efficiency, fat content in milk or daily fat and protein efficiency. The FA profile in milk was more determined by the lactation phase than by the feed type. Feed conversion, estimated with the amount of ECM milk produced from 1 kg DM ration was similar, though the highest DM use efficiency was noted in cows fed CCM in the first phase of lactation. Nitrogen use efficiency was higher in cows fed HMC. The use of simplified corn harvest technology in the form of corn cobs (CCM) may be the alternative for traditional harvest with a harvester which lowers the feeding costs of high-yielding dairy cows.

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Received 22 February 2012
Accepted 13 April 2012