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The Effect of Rapeseed Cake Fed Without or With Citric Acid in the Sows' Diets on Their Reproductive Performance and Chemical Composition of Colostrum and Milk

Wpływ makuchu rzepakowego skarmianego bez lub z dodatkiem kwasu cytrynowego w mieszankach dla loch na ich reprodukcję i skład chemiczny siary i mleka

Shortage of protein sources and also high-energy feedstuffs determine the increased interest in the local feeds as an alternative for soybean meal and also for some fat sources. Among these feeds the rapeseed cake should be taken into consideration. Its energy value is higher than the rapeseed extracted meal and, in comparison with the seeds of rape, it contains more protein. The studies which have been carried out hitherto proved the usefulness of rapeseed cake in feeding of fattening pigs (Fuchs et al. 1995). There are not many publications however relating to rapeseed cake utilization in the diets for sows (Krasucki 1997). Taking into consideration relatively high protein and energy requirements of lactating sows, the rapeseed cake can be an appropriate component of full-feed diets for these animals. Besides, the fatty acids contained in rapeseed cake fat (10–12%) can positively affect some reproductive characteristics of sows (Tywończuk et al. 1997). An additive of organic acids to the young pig diets decreases pH in the diet (and also gastric pH) and reduces the incidence of diarrhoea; it increases daily gains, digestibility of nutrients and feed efficiency (Partanen and Mroz 1999).

The aim of these studies was to determine the influence of rapeseed cake (RC) and citric acid (CA) additives to the pregnancy and lactation diets of sows on dry matter, ash, lactose, fat and protein content in colostrum and milk and on amino acid composition of protein and fatty acids content in their fat.

MATERIAL AND METHODS

The studies were carried out on thirty-six primiparous sows (Polish Landrace x Polish Large White) throughout pregnancy and then during lactation (35 days). The sows were mated by Large White breed boars and were housed in individual stalls for 110 days and afterwards transferred into farrowing pens (1.6 x 1.8 m). Average ambient temperature in the pregnancy unit was about 20^0C, and in the farrowing unit – about 23^0C. The animals had free access to water. Sows were randomly divided in 3 groups, 12 animals each. Experimental diets composition is shown in Table 1. The animals of group I – control were fed with the commercial-standard full feed mixtures. The mixtures for groups II and III contained rapeseed cake (5 and 10% in diets for pregnancy and lactation, respectively) and the sows of group III received the additive of 2 % citric acid to the diets. Sows were fed individually, according to Nutrient Requirements of Pigs (1993). The fed mixtures had loose form.

The nutrient content in the feed mixtures was analysed using standard methods (A O A C 1990). Besides, the content of the minerals was determined in the mixtures by atomic absorption spectrophotometry after ashing the samples at 460^0C and preparing mineral solution in 0.48 *M* HCl. Total P was determined colorimetrically with vanadium molybdate procedure (A O A C 1990). The glucosinolates content was determined using HPLC (Michalski et al. 1995).

The colostrum samples were taken in 20 – 24 h after parturition and milk in about 3 h after the morning feeding on 7^{th}, 14^{th} and 21^{st} days of lactation from 8 sows of each group after injection of 2 ml oxytocin. Colostrum and milk were milked by hand from the same pair of nipples, i.e. 2nd, 4th and 6th (counting from front), until the entire draining of the mammary gland. The cows were milked about 3 h after the morning feeding. The dry matter, ash, protein, ether extract and lactose contents in colostrum and milk samples were determined by classical methods (A O A C 1990) and their energy values were estimated using the regression equations by Bakke and Vold (1975). Amino acids (excluding methionine, cysteine and tryptophan) were analyzed by Amino Acid Analyzer T 339M (Microtechna, Praha) using the proper acid protein hydrolyzates. Cysteine and methionine before hydrolysis were oxidized with performic acid. Tryptophan content was determined with spectrofotometric method using p–dimethylamino-benzoic aldehyde (DMAB). The colostrum and milk fat as well as rapeseed cake fat composition, after saponification and esterification with 14% BF_3 in methanol, were determined by gas chromatography method on GC 505 apparatus. Every fatty acid was expressed as the percentage of FA sum.

The results were subjected to analysis of variance for a completely randomized design with three treatments (control; rapeseed cake supplement; rapeseed cake + citric acid supplements) and the mean values were statistically compared by the Student t –test at $p \leq 0.05$.

RESULTS AND DISCUSSION

The rapeseed cake used in this experiment contained 12.5 % crude fat. Fat of the rapeseed cake contained 6.8% palmitic, 2.1% stearic, 59.7% oleic, 21.6% linoleic, 6.8% linolenic and 0.03% erucic acids. There was found 12.3 µmol glucosinolates per 1 g of fat-free rapeseed cake. The diets containing 10% rapeseed cake had by 1.3% higher ether extract content in comparison with the mixtures for control group (Table 1). Also lysine and sulphur amino acids contents were somewhat higher in these mixtures. All the mixtures used in the experiment were eaten willingly, irrespective of the content of the components in the diets.

Table 1. Composition (%) and nutritive value of diets for sows

Item	Group I		Group II	
	pregnancy	lactation	pregnancy	lactation
Barley	53.5	46.8	60.5	42.8
Soybean meal	2.0	7.0	0.0	0.0
Wheat bran	20.0	20.0	10.0	20.0
Wheat	20.0	20.0	20.0	20.0
Rapeseed cake (RC)	0.0	0.0	5.0	10.0
Fish meal	2.0	4.0	2.0	5.0
L-lysine HCL (78%)	0.0	0.2	0.0	0.2
Limestone	1.0	0.5	1.0	0.5
Trace mineral-vitamin premix	1.5	1.5	1.5	1.5
Content in 1 kg of mixture:				
ME, MJ	11.9	11.8	12.7	12.8
Crude protein, g	128.2	167.3	126.4	167.2
Ether extract, g	27.4	32.1	34.0	45.3
Ca, g	6.9	8.1	7.0	8.2
Total P, g	4.9	6.2	5.1	6.3
Lys, g	5.2	8.1	5.0	8.2
Met + Cys, g	3.7	5.2	3.6	5.1

Table 2. Reproductive performance of sows

Item	Feeding group			*SEM*
	I	II	III	
Body weight at mating (kg)	107.4	108.2	107.9	8.4
Body weight gain during pregnancy (kg)	59.7	63.3	63.9	2.6
Loss of body weight at parturition (kg)	22.6^{a}	25.3^{b}	24.7^{ab}	1.7
Loss of body weight during lactation (kg)	16.3	17.1	17.2	1.5
Number of piglets:				
liveborn	9.8^{a}	10.1^{ab}	10.8^{b}	1.12
at 21-st day of age	9.5^{a}	9.8^{ab}	10.4^{b}	1.07
at 35 days of age (weaned)	9.3^{a}	9.6^{ab}	10.2^{b}	1.01
Body weight of piglets in days, kg:				
1 st	1.2	1.2	1.3	0.07
21 st	6.1	6.3	6.5	0.12
35 th (weaned)	9.2	9.3	9.5	0.31
Total feed intake during pregnancy (kg)	275.2	276.0	274.8	7.3
Total feed intake during lactation (kg)	154.9	155.5	153.4	6.4

$^{a, b}$ Means within rows with different superscript letters are different ($P \leq 0.05$);
SEM – standard error of the mean, n = 12

Table 3. Basic chemical composition of sows colostrum and milk (%)

Chemical ingredients	Feeding group	Lactation day			
		colostrum	7th	14th	21st
Dry matter	I	22.82	18.62	17.62	17.41
	II	22.71	18.71	17.61	17.42
	III	22.91	18.92	17.81	17.62
	SEM	0.69	0.71	0.73	0.72
Total protein	I	12.91	5.92	5.32	5.21
	II	12.81	5.81	5.22	5.22
	III	12.92	5.91	5.41	5.33
	SEM	0.37	0.26	0.24	0.27
Ether extract	I	5.12	7.42	7.22	7.12
	II	5.31	7.61	7.41	7.21
	III	5.32	7.62	7.42	7.31
	SEM	0.23	0.43	0.39	0.41
Lactose	I	3.91	4.22	4.12	4.21
	II	3.81	4.21	4.11	4.12
	III	3.92	4.42	4.32	4.33
	SEM	0.17	0.23	0.22	0.20
Total ash	I	0.69	0.82	0.84	0.87
	II	0.67	0.81	0.85	0.92
	III	0.68	0.82	0.90	0.92
	SEM	0.03	0.02	0.01	0.02
Total energy kJ/kg	I	4940.1	4617.5	4588.3	4587.7
	II	4976.8	4631.2	4599.9	4597.8
	III	4978.7	4636.7	4601.9	4594.8
	SEM	12.2	10.4	10.8	11.2

SEM – standard error of the mean, n = 12

Table 2 shows the reproductive performance of sows. Rapeseed cake in the mixtures did not have any influence on the reproductive parameters of sows. The additive of citric acid to the diet (group III) increased ($p \leq 0.05$) by 0.9 the number of liveborn and weaned piglets in the litter in comparison with control group. There is lack of reports in available papers relating to the problem of citric acid utilization in sows' feeding.

The content of basic nutrients in colostrum was not considerably dependent on the participation of rapeseed cake in the mixtures (Table 3). Only ether extract content and gross energy value were somewhat higher in sows colostrum or milk from group II and III sows, but the differences were statistically insignificant. A similar tendency was noted in the composition and energy value of milk. There was also a tendency of slight decrease of protein and fat content towards the end of lactation, which seems to be a general regularity confirmed by Csapó et al. (1996).

Table 4. Amino acid composition of protein of sows' colostrum and milk (% of crude protein)

Amino acids	Colostrum feeding group			*SEM*	Milk feeding group			*SEM*
	I	II	III		I	II	III	
Lys	7.1	7.2	7.3	0.2	7.0	7.1	7.2	0.2
Met	1.6	1.7	1.7	0.1	1.7	1.8	1.8	0.1
Cys	1.9	1.8	1.9	0.1	1.9	1.8	1.8	0.1
Thr	4.1	4.2	4.3	0.1	4.0	4.1	4.1	0.1
Ile	3.2	3.3	3.3	0.1	3.2	3.3	3.3	0.1
Trp	2.5	2.4	2.4	0.1	2.2	2.3	2.3	0.1
Val	4.1	4.2	4.2	0.1	4.1	4.1	4.1	0.1
Leu	7.8	7.9	7.9	0.1	7.6	7.6	7.7	0.1
His	2.7	2.8	2.7	0.1	2.5	2.6	2.6	0.1
Arg	4.5	4.8	4.9	0.1	4.4	4.6	4.7	0.1
Phe	3.8	3.6	3.7	0.1	3.6	3.5	3.6	0.1
Tyr	3.7	3.4	3.5	0.1	3.4	3.3	3.4	0.1
Asp	8.7	8.6	8.6	0.2	8.6	8.5	8.5	0.2
Ser	5.1	5.0	5.0	0.2	5.0	4.9	4.9	0.2
Glu	17.8	17.4	17.5	0.3	17.9	17.7	17.6	0.3
Pro	9.5	9.3	9.2	0.2	9.8	9.9	9.9	0.2
Gly	3.7	3.8	3.9	0.1	3.6	3.7	3.8	0.1
Ala	3.7	3.8	3.9	0.1	3.6	3.7	3.7	0.1

SEM – standard error of the mean, n = 8

Table 5. Fatty acid composition of sows colostrum and milk fat (% of the sum of fatty acids)

Fatty acid	Colostrum feeding group			*SEM*	Milk feeding group			*SEM*
	I	II	III		I	II	III	
Myristic – $C_{14:0}$	2.4	2.2	2.1	0.19	3.9	3.6	3.5	0.24
Palmitic – $C_{16:0}$	25.7	24.3	24.1	1.23	30.4	29.3	28.7	1.47
Palmitoleic – $C_{16:1}$	6.8	6.4	6.2	0.31	9.7	9.4	9.2	0.32
Stearic – $C_{18:0}$	5.7	5.8	5.9	0.24	5.2	5.3	5.4	0.28
Oleic – $C_{18:1}$	39.8	40.2	40.4	1.47	36.9	37.6	37.2	1.41
Linoleic – $C_{18:2}$	17.5	18.5	18.9	0.26	11.2	11.6	11.9	0.19
Linolenic – $C_{18:3}$	0.9	1.0	1.2	0.08	0.7	0.8	0.9	0.07
Arachidonic – $C_{20:4}$	0.7	0.8	0.9	0.06	0.6	0.7	0.8	0.04
Saturated FA	33.8	32.3	32.1	1.14	39.5	38.2	37.6	1.17
Monoenic FA	46.6	46.6	46.6	2.29	46.6	47.0	46.4	2.37
Polyenic FA	19.1^{a}	20.3^{ab}	21.0^{b}	0.19	12.5^{a}	13.1^{ab}	13.6^{b}	0.14
Ratio UFA : SFA	1.94	2.07	2.11	0.02	1.49	1.57	1.60	0.05

$^{a, b}$ Means within rows with different superscript letters are different ($P \leq 0.05$);

SEM – standard error of the mean, n = 8

There were not noted any considerable changes in amino acids composition of colostrum and milk protein, caused by the rapeseed cake and citric acid supplements (Table 4).

Colostrum and milk fat contains high level of palmitic, oleic and linoleic acids (Table 5). These data confirm the results received by Migdal et al. (1993). Colostrum fat of sows receiving rapeseed cake (group II) or rapeseed cake + citric acid (group III) had by 1.0–1.4 percentage units higher content of linoleic acid in comparison with control, but the differences were not significant statistically. Also, milk fat of sows of these groups had an elevated level of this acid. Rapeseed cake supplement caused a significant ($p \leq 0.05$) increase of polyunsaturated fatty acids content in colostrum and milk fat. The increase was equal to 1.9 and 1.1 percentage units, respectively. Similar relations were found in the studies carried out by W i e l b o (1995), where the supplement of 6% rapeseed oil was used. The citric acid additive did not have any influence on colostrum and milk fat composition.

CONCLUSIONS

1. The 10% supplement of rapeseed cake added solely or together with 2% additive of citric acid to the lactating sows diets did not considerably influence the content of nutrients or the energy value of sows' colostrum and milk and did not change amino acid composition of their protein.

2. The content of polyunsaturated fatty acids in colostrum and milk fat was by 1.9 and 1.1 percentage units higher at sows fed the diet with 10% of rapeseed cake and 2% citric acid supplement.

3. The additive of 2% citric acid considerably increased the number of weaned piglets in the litter.

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STRESZCZENIE

Doświadczenie przeprowadzono na 36 loszkach mieszańcach (pbz x wbp), podzielonych na 3 grupy. Badania prowadzono w okresie ciąży, a następnie w czasie laktacji (35 dni). Grupa I żywiona była mieszankami standardowymi z udziałem śruty poekstrakcyjnej sojowej i mączki rybnej. W mieszankach dla grup II i III śrutę poekstrakcyjną sojową zastąpiono makuchem rzepakowym. Mieszanka dla grupy III zawierała makuch rzepakowy oraz 2% kwasu cytrynowego. Dawki pokarmowe były izobiałkowe. Od loch pobrano próby siary (pierwsza doba) oraz mleka w 7, 14, 21 dniu laktacji. W siarze i mleku loch oznaczono zawartość suchej masy, popiołu surowego, tłuszczu surowego i białka ogólnego. Określono również skład aminokwasowy białka oraz skład kwasów tłuszczowych w tłuszczu siary i mleka. Dodatek 10% makuchu rzepakowego do dawek pokarmowych dla loch karmiących nie wpłynął istotnie na zawartość podstawowych składników pokarmowych siary i mleka. Przy stosowaniu tego dodatku wzrosła jedynie zawartość wielonienasyconych kwasów tłuszczowych w tłuszczu siary i mleka. Równoczesne zastosowanie makuchu rzepakowego oraz 2% kwasu cytrynowego podwyższyło liczbę urodzonych i odsadzonych prosiąt o blisko jedną sztukę na miot, nie wpłynęło zaś istotnie na skład chemiczny siary i mleka.