Scientific Annals of Polish Society of Animal Production - Vol. 11 (2015), No 2, 71-79

Meat chemical composition and blood serum lipids of pigs fed mixtures containing barley or triticale

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A feeding experiment was carried out on 24 hybrid (PIC 408 x Camborough 24) fatteners in order to investigate the effect of mixtures containing barley or triticale meal on the basic nutrient content and fatty acid profile of the *longissimus lumborum* and *adductor* muscles, as well as the concentration of triglycerides and cholesterol in the blood serum. The kind of grain in the mixtures was found to have no statistically significant effect on the content of basic nutrients (protein, fat and ash) or the fatty acid profile (except C14:0 and C20:1 fatty acids in *m. adductor*) in either of the muscles. However, in the pigs fed triticale mixtures a slight decrease was observed in intramuscular fat, which contained a bit more polyunsaturated fatty acids (mainly linoleic acid), as well as a decrease in the level of the analysed blood indicators.

KEY WORDS: fatteners / *m. longissimus lumborum, adductor* / basic nutrients / fatty acids / cholesterol

Pork, the most popular meat among Polish people, is a source of complete protein but also a considerable amount of cholesterol and saturated fatty acids (SFA). A high level of pork consumption may create the risk of cardiovascular disease. The World Health Organization (WHO, 2003) recommends that a maximum of 30% of the energy in the human diet should be obtained from fat, including up to 10% from saturated fatty acids (SFA) and 6-10% from polyunsaturated fatty acids (PUFA). A very important factor is the ratio of *n-6* PUFA to *n-3* PUFA, which should be 4-5:1. Hypolipidaemic and hypocholesterolaemic effects are ascribed to these acids [10, 23]. As pork fat does not meet these requirements [14], one of the current tasks of pork producers is to obtain a more beneficial fatty acid composition in intramuscular and intermuscular fat. According to Wood et al. [27] and Raj et al. [20], the fatty acid profile of the lipid fraction can be modified by dietary factors.

An indispensable component of the diet of fattening pigs is cereal meals, which constitute over half of the feed ration. The most popular cereal is barley. Triticale produces similar results in pig fattening [2, 4, 25] and can replace not only barley in compound feeds for pigs but also maize or wheat, with no negative consequences [4, 8, 13]. Triticale can even be the only cereal in compound feeds for broiler chickens. According to Chapman et al. [3], Józefiak et al. [11] and Santos et al. [21], it has no detrimental effect on the final body weight of the birds. Moreover, a study by Osek et al. [17] showed that the use of triticale alone in the diet of chickens significantly increased the proportion of essential fatty acids (linoleic and linolenic acids) in the intramuscular fat of the birds.

These reports inspired us to carry out a study to test whether triticale in the diet of fattening pigs, similarly affects the fatty acid profile of meat lipids, as well as the serum content of triglycerides and cholesterol, as in the case of broiler chickens.

Material and methods

A feeding experiment was carried out on a private farm on 24 crossbred pigs (PIC 408 x Camborough 24) divided into groups of equal size, a control (J) and an experimental group (P). The pigs were fattened from a mean body weight of 30.5 kg to about 110 kg, in two feeding periods. The first period (to a body weight of 70 kg) lasted 53 days, and the second (until slaughter) 39 days. The animals were housed in group pens on deep litter, with four pigs per pen, and fed ad libitum mixtures prepared from barley meal (group J) or triticale (group P). During fattening the feed intake and weight gain of the animals was monitored. After the fattening period all animals were slaughtered in accordance with generally accepted procedures. During slaughter blood was collected for determination of the content of total cholesterol, its high-density lipoprotein fraction (HDL), and triglycerides, which were analysed by enzymatic methods using diagnostic tests from Alpha Diagnostics. The low-density lipoprotein fraction of cholesterol (LDL) was calculated by Friedewald's formula (LDL = TC – (HDL + TG/5)), using the previously determined concentrations of total cholesterol (TC), HDL cholesterol and triglycerides (TG).

During dissection of the right half-carcasses, meat samples were taken from the longissimus lumborum muscle (LL) and the adductor muscle, semimembranosus of the ham. The content of basic components was determined in the muscles, i.e. protein, fat and ash [1]. The composition and proportions of fatty acids in the lipids of both muscles were determined by gas chromatography of methyl esters using a CHROM-5 gas chromatograph with a flame ionization detector.

The results obtained were analysed statistically by one-way analysis of variance, and significance of differences between means were verified by Student's t-test [24].

Results and discussion

The composition and nutritional value of the feed mixtures is presented in Table 1. The proportions of cereals and protein feed in the experimental mixtures were similar in

Table 1
Composition (%) and nutritive value of the experimental mixtures

Specification	Feeding groups			
	J		P	
	1st period of fattening	2nd period of fattening	1st period of fattening	2nd period of fattening
Ground barley	80.50	86.00	–	–
Ground triticale	–	–	80.00	85.50
Soybean meal	16.50	12.00	17.20	12.50
L-lysine	0.10	0.10	0.10	0.10
Dicalcium phosphate	1.10	0.30	0.80	0.30
Fodder salt	0.30	0.25	0.30	0.25
Limestone	1.00	0.85	1.10	0.85
Premix*	0.50	0.50	0.50	0.50
Nutritive value of 1 kg mixtures:				
metabolizable energy (MJ)	12.27	12.39	13.02	13.16
crude protein (g)	160.3	147.1	169.9	156.3
lysine (g)	8.52	7.53	8.84	7.91
methionine + cystine (g)	5.37	5.03	5.60	5.25
calcium (g)	7.01	4.62	6.78	4.64
phosphorus (g)	5.96	4.40	5.42	4.40
sodium (g)	1.32	1.11	1.32	1.11

*1 kg of premix for 1st period of fattening contains: vitamin A – 500,000 IU, vitamin D_3 – 100,000 IU, vitamin B_1 – 60 mg, vitamin B_2 – 200 mg, vitamin B_{12} – 1000 mcg, niacin – 810 mg, pantotenic acid – 420 mg, folic acid – 80 mg, manganese – 1,600 mg, zinc – 3,800 mg, selenium – 12.2 mg, enzyme beta-xylanase – 2,800 U, enzyme beta-glucanase – 4,100 U; 1 kg of premix for 2nd period of fattening contains: vitamin A – 400,000 IU, vitamin D_3 – 80,000 IU, vitamin B_1 – 60 mg, vitamin B_2 – 150 mg, vitamin B_{12} – 1,000 mcg, niacin – 800 mg, pantotenic acid – 400 mg, folic acid – 40 mg, manganese – 1,800 mg, zinc – 3,900 mg, selenium – 12 mg, calcium – 400g, enzyme beta-xylanase – 2,800 U, enzyme beta-glucanase – 4,100 U

the first and second fattening period. The introduction of triticale to the mixtures resulted in an increase in metabolic energy (calculated from the energy value of the raw materials), but the required protein and lysine content per MJ ME was in compliance with the recommendations given in Swine Feeding Standards [16].

The chemical analysis of the longissimus lumborum and adductor muscles (Figs. 1 and 2) revealed no significant effect of the type of cereal used in the feed on the content of basic nutrients. However, less crude fat was noted in the muscles of the experimental pigs (group P). Chapman et al. [3] also report lower (1.82% vs. 1.91%) intramuscular fat content in the longissimus muscle of pigs whose feed contained triticale as compared to pigs receiving feed with barley.

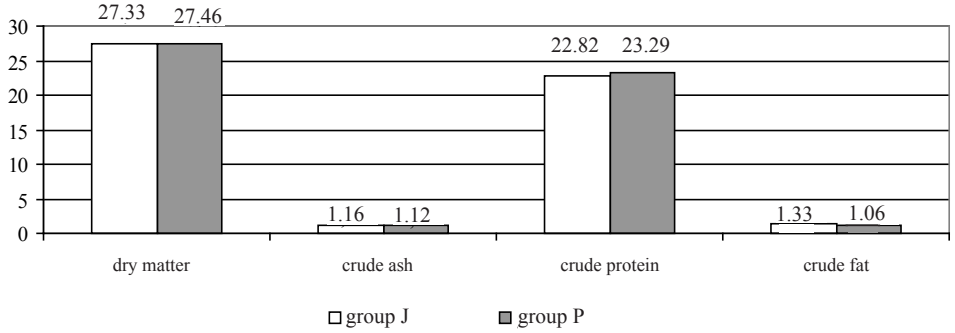

Fig. 1. Chemical analysis of *longissimus lumborum* muscle

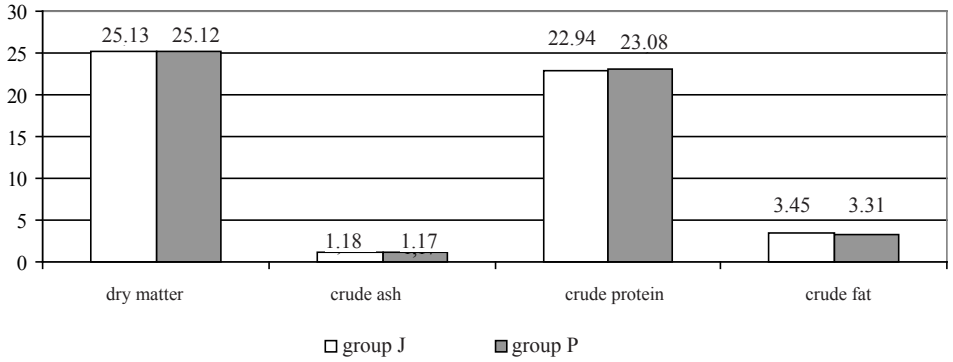

Fig. 2. Chemical analysis of *adductor* muscle

Table 2 presents the fatty acid composition of the lipid fraction of the longissimus lumborum and adductor muscles. The statistical analysis revealed a significantly higher content of myristic acid (C14:0) and eicosenoic acid (C20:1) in the adductor muscle of pigs receiving the feed with triticale (group P). No statistical differences were noted in total saturated fatty acids (SFA), which accounted for 33.62% to 36.94% of total fatty acids, or unsaturated fatty acids (UFA), whose share in the total fatty acids ranged from 62.90% to 66.19%. The type of cereal used in the feed also had no statistically significant effect on the level of polyunsaturated fatty acids (PUFA), which are particularly important in the human diet, but their share was slightly higher in the muscles of the animals receiving feed with triticale.

Table 2
Fatty acid profile of *longissimus lumborum* and *adductor* muscles

Fatty acids	Type of muscle					
	m. longissimus lumborum			*m. adductor*		
	Feeding groups					
	J	P	SEM	J	P	SEM
C14:0	0.52	0.50	0.038	0.37^{b}	0.53^{a}	0.028
C16:0	27.01	27.22	0.329	25.55	24.92	0.475
C16:1	2.75	2.55	0.081	2.68	3.07	0.125
C18:0	9.18	9.19	0.607	7.69	8.34	0.257
C18:1	57.03	56.56	0.972	58.30	56.98	0.390
C18:2 *n-6*	2.92	3.43	0.364	4.64	5.15	0.221
C18:3 *n-3*	0.04	0.06	0.009	0.05	0.08	0.005
C20:0	0.03	0.03	0.004	0.01	0.03	0.004
C20:1	0.21	0.21	0.019	0.16^{B}	0.27^{A}	0.004
C20:2 *n-6*	0.04	0.03	0.007	0.03	0.06	0.006
C20:4 *n-6*	0.08	0.06	0.013	0.33	0.40	0.032
Other	0.19	0.16	0.007	0.19	0.17	0.012
SFA	36.74	36.94	0.898	33.62	33.82	0.577
UFA	63.07	62.90	0.901	66.19	66.01	0.577
MUFA	59.99	59.32	0.926	61.14	60.32	0.414
PUFA	3.08	3.58	0.369	5.05	5.69	0.257
n-6/n-3	76	59	10.553	100	64	11.521
DFA	72.25	72.09	0.313	73.86	74.35	0.501
OFA	27.53	27.72	0.312	25.92	25.45	0.494

A, B – $P \leq 0.01$; a, b – $P \leq 0.05$
SFA – saturated fatty acid; UFA – unsaturated fatty acid; MUFA – monounsaturated fatty acid; PUFA – polyunsaturated fatty acid; DFA – neutral and hypocholestero-lemic fatty acid (UFA+C18:0); OFA – hypercholesterolemic fatty acid (C14:0+C16:0)

Table 3
Serum lipid indices of fatteners

Lipid indices	Feeding groups		
	J	P	SEM
Total cholesterol (mg/dl)	88.4	86.8	4.794
HDL (mg/dl)	34.2	33.8	1.039
LDL (mg/dl)	48.2	47.3	5.749
Triglycerides (mg/dl)	29.6	28.4	1.876

Simopoulos [22, 23] and Jelińska [10] emphasize that polyunsaturated fatty acids, particularly of the *n-3* family, are a significant component of food. It is recommended that the ratio of PUFA *n-6* to PUFA *n-3* in the human diet should be less than 4; otherwise it may be a risk factor for cancer and ischaemic heart disease [18, 19]. The present study showed that in both muscles analysed there was a substantial, though statistically unconfirmed reduction in the unfavourable *n-6/n-3* ratio in the experimental pigs.

However, it is difficult to compare the results of this study with those obtained by other authors, due to the lack of research strictly connected with this subject.

Literature data [5, 6, 7, 9] indicate that the fatty acid profile of pork is affected not only by diet [7], but also by the breed and body weight of the pigs. Grześkowiak et al. [6] and Jacyno et al. [9] demonstrated that meat obtained from pigs with high meat content has higher content of polyunsaturated fatty acids, mainly linoleic acid, which improves its dietary value, but according to Migdał et al. [15] has a negative effect on its palatability. Gardzińska and Migdał [5] state that fattening of pigs to a greater body weight reduces the content of hypocholesterolaemic acids in the meat lipids, which is an unfavourable phenomenon.

Only Sullivan et al. [25], who used a 40% or 80% share of triticale in compound feed, found that it had no effect on the fatty acid profile of the longissimus dorsi muscle, which is in agreement with the results obtained in the present study.

The level of serum lipid indices (Tab. 3) was similar in both groups of pigs.

According to Winnicka [26], the reference values in the blood of adult pigs show substantial fluctuations in the concentrations of both triacylglycerols (41-83 mg/dl) and total cholesterol (19.4-81.3 mg/dl). In the present study, the total cholesterol level was higher than the upper level given by the author cited. In the animals whose feed contained triticale (P) there was a statistically insignificant reduction in the level of triglycerides, but also in the high-density lipoprotein fraction (HDL), accompanied by an increase in the low-density fraction (LDL).

According to Pond et al. [19], the total cholesterol concentration in the blood depends mainly on genetic factors (breed, cross-breeding scheme, and sex), feeding, and endogenous production of this compound in the liver. Cholesterol content in the blood serum

also changes with the age of pigs. For example, Kapelański et al. [12] reported cholesterol levels of 93.2 mg/dl and 110.6 mg/dl in pigs in the first and second stages of fattening.

To sum up, the results obtained indicate that triticale can be recommended as the only cereal in compound feeds for fattening pigs, because the meat obtained has comparable nutritional value to that obtained using barley and somewhat better nutritional properties (lower fat content and a more beneficial fatty acid profile), while having no negative effect on blood lipid indices.

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