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Meat quality in pigs fed mixtures with low-tannin faba bean

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Abstract: *Meat quality in pigs fed mixtures with low-tannin faba bean.* The aim of the study was to evaluate slaughter values of carcasses and meat (*Musculus longissimus lumborum*, *Musculus semimembranosus*) quality in pigs fed mixtures with faba beans. Research included 48 fatteners, which were divided into three feeding groups. Pigs in group I were fed mixtures in which extracted soybean meal was used as the only high-protein raw material, whereas animals in groups II and III were fed mixtures with 5/10% or 10/20% of low-tannin faba bean in grower/finisher mixtures respectively. It was proved, that introduction of faba bean into mixtures increased of meatiness and loin "eye" area and decreased of carcass fatness. The significant increase in the share of the most valuable exogenous fatty acids ($C18:2_{n-6}$, $C18:3_{n-3)}$ in muscles of animals from groups II and III were found. *Musculus longissimus lumborum* in pigs fed mixtures with faba beans were characterized by significantly better water holding capacity WHC ($P \leq 0.01$).

Key words: faba beans, carcass yield, pork, physical properties, chemical composition

INTRODUCTION

High-protein raw materials are essential components in feed mixtures for desirable pig growth. The extracted soybean meal is the most commonly used source of protein in animal feeding. It is estimated that approximately 98% of soybean comes from genetically modified seeds. Some research proved that genetic modification did not affect not only the nutritional value of soybean meal, but also fattening and slaughter performance and meat quality (Flachovsky et al. 2005, Hanczakowska and Świątkiewicz 2014). Furthermore, Świątkiewicz et al. (2011) did not prove that the transgenetic DNA can be transferred from feeds to animal tissues. Despite these findings, consumers in Poland and many other countries are unwilling to accept products made from genetically modified plants. The price of imported soybean meal and the possibility of banning the application of the genetically modified feeds in animal feeding are good reasons to start searching for alternative protein sources in pig feeding. Underestimated *Fabaceae* seeds, including faba bean seeds, can be the basic domestic source of protein in feed mixtures. Low-tannin varieties of faba bean give an opportunity to apply them more widely in pig feeding (Jezierny et al. 2010, Milczarek and Osek 2016). Every change in the composition of feed mixtures for fattener pigs can influence both productive indices and meat quality, including its dietary and

gustatory values (Gatta et al. 2013, Milczarek and Osek 2014b, Milczarek and Osek 2016). The previous studies (Zijlstra et al. 2008, Smith et al. 2013, Hanczakowska and Świątkiewicz 2014, Milczarek and Osek 2016) did not lead to the unambiguous conclusion that low-tannin faba bean had positive effect on the parameters mentioned above and did not answer the question what the optimal level of the feed can be applied in mixtures.

The research, therefore, was undertaken and its aim was to evaluate slaughter values of carcasses and meat quality in slow-growing breed pigs, which were fed mixtures with different contents of low-tannin faba bean Amulet variety.

MATERIAL AND METHODS

The feeding experiment was conducted on 48 slow-growing fatteners with a mean body weight 28 kg that were divided into three equal feeding groups (I, II and III), each of 16 pigs. Pigs were raised using a two-phase dietary feeding program where the first-phase diets (grower) were fed for 64 days and the second-phase diets (finisher) were fed for 55 days. The animals were fed mixtures that contained barley, extracted soybean meal, oil and mineral-vitamin additives. The extracted soybean meal was the only high-protein raw material in mixtures for fatteners in the first group (control), whereas in experimental mixtures in groups II and III, the soybean meal was partially replaced by 5 and 10% of low-tannin faba bean meal Amulet variety in grower mixtures as well as 10 and 20% in finisher mixtures, respectively. The Nutritional Recommendations for Pigs (2015) was used to formulate isoprotein (160/147 g protein) and isocaloric (13,2/12,8 MJ ME) grower/finisher feed mixtures.

The fatteners were slaughtered at the average body weight 120 kg according to the technology required in meat processing plants and carcass meatiness was estimated using the Ultra-Fom 300 apparatus. The initial acidity (pH_1) in the *longissimus* muscles (between the last pectoral vertebra and the first lumbar vertebra) was measured 45 min after the slaughter by means of the portable pH-meter that was equipped with a glass electrode. Next the carcasses were chilled for 24 h at a temperature of 0–4°C. After that the pH_{24} of *longissimus* muscles were measured then carcass length, backfat thickness and height and width of loin were measured using the right halves of carcass. The carcass length was measured from the anterior edge of the symphysis pubis to the recess of the first rib. The backfat thickness were five points on the right lying half-carcasses: in the thickest point above the shoulder blade, on the back above the joint between the last pectoral vertebra and the first lumbar vertebra, and on three points on the lower back (at the level of sacral vertebrae: I, II, III).

Next the samples of *musculus longissimus lumborum* and *musculus semimembranosus* were determined for the physicochemical and organoleptic properties. Water holding capacity (WHC) of muscles were determined according to Grau and Hamm's (1953) method. Moreover, drip loss after 48 and 72 h *post mortem* were determined using methods practiced by Prange et al. (1977). The instrumental evaluation of

meat colour was performed by means of the photocolorimeter in the system CIE L*a*b*, where L* represented the lightness of a colour that was the spatial vector, whereas a* and b* were trichromatic coordinates. The chroma index (C) and the colour hue (H) were calculated using the results of colour parameters a* and b* (Strzyżewski et al. 2008, Milczarek and Osek 2016). The content of basic nutrients (dry matter, crude ash, crude protein, crude fat) were tested according to AOAC (2005). Fatty acids profile of the lipid fraction determined by gas chromatography of methyl esters in a Varian 450-GC fitted with a flame ionisation detector (air-hydrogen).

The obtained results were statistically analyzed with the Statistica software ver. 12 (StatSoft Inc., Tulsa, USA). The arithmetic means and standard deviations (SD) for all features in groups were calculated. One-way analysis of variance were used. The significance of differences between means were evaluated with the Duncan's test.

RESULTS AND DISCUSSION

Introducing low-tannin faba bean to mixtures for fatteners did not affect the dressing percentage (Table 1). Better meatiness and larger loin "eye" area were found in pigs fed mixtures with faba bean, however, statistically significant differences were proved only between groups III and I (control). The carcass fatness of fatteners II and III groups was lower than of the control group, due to the fact that the carcasses were characterized by significantly thinner backfat that was measured above the

TABLE 1. Post-slaughter results of fatteners

Item	Groups						*P*
	I		II		III		
	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	
Dressing percentage (%)	77.02	2.39	74.89	2.09	75.07	2.01	>0.05
Meatiness (%)	51.59b	1.25	52.05ab	1.27	52.95a	1.28	≤0.05
Carcass length (cm)	84.60	1.25	86.80	1.30	85.90	1.24	>0.05
Backfat thickness (mm)							
over the shoulder	32.13A	1.50	28.50B	1.79	28.00B	1.36	≤0.01
mid back	40.00	1.30	39.25	1.57	40.75	1.44	>0.05
sacrum I	35.38a	1.23	31.88b	1.33	32.75ab	1.46	≤0.05
sacrum II	30.50A	1.26	24.63B	1.39	22.38B	1.26	≤0.01
sacrum III	32.13a	1.49	27.88b	1.64	27.63b	1.45	≤0.05
$\bar{x}$ from 5 measurements	34.03A	1.27	30.23B	1.38	29.60B	1.22	≤0.01
Lard weight (kg)	2.55	0.42	2.48	0.35	2.37	0.29	>0.05
Loin "eye" area (cm^2)	50.40B	1.53	50.46B	1.58	52.95A	1.48	≤0.01

A, B or a, b – means within the same rows with different letter differ significantly $P \leq 0.01$ or $P \leq 0.05$.

shoulder blade as well as in lower back II and III, which resulted in lower backfat thickness mean from five measurements by approximately 4 mm ($P \leq 0.01$). Zijlstra et al. (2008) and Smith et al. (2013) stated that feed mixtures with different contents of faba bean meal did not significantly influence carcass fatness, however, larger content of faba bean (30%) in mixtures significantly ($P < 0.05$) decreased the dressing percentage and the backfat thickness (Zijlstra et al. 2008). On the other hand, Smith et al. (2013) did not indicate the influence of the faba bean meal (7.5, 15, 22.5 and 30%) on either dressing percentage or carcass meatiness. The results found in the present studies, i.e. lower carcass fatness and better carcass meatiness after applying low-tannin faba bean in mixtures for pigs, were consistent with the results presented in earlier studies by Milczarek and Osek (2014a).

Many physical parameters (pH, colour, water holding capacity, drip loss) determine the meat quality characteristics of pork. The partial substitution of extracted soybean meal by faba bean meal with a low level of tannins in feed mixtures for fatteners did not influence the muscle acidity measured at 45 min and 24 h after slaughter (Table 2).

Scheffler and Gerrard (2007) stated that the ultimate meat quality and its technological properties depend on the rate and range of the decrease in the pH value *post mortem*. Acidification of muscles 24 h *post mortem* (pH_{24}) amounted to 5.6–5.7, which was typical of the highest quality meat – the *longissimus lumborum* and *semimembranosus* muscles (Tomović et al. 2013). The high acidification (pH <5.5) of the muscle tissues 24 and 48 h *post mortem* indicates worse culinary and technological properties of the meat and results in receiving acid meat – the kind of meat is characterized by large losses during the heat treatment.

Strzyżewski et al. (2008) proved that the pH value greatly influenced meat colour, which undoubtedly is an essential meat quality characteristic that determines the appearance of meat and its attractiveness in the eyes of consumers. No significant effects of the application of faba bean in experimental mixtures on lightness of a colour (L*) and the saturation of a red colour (a*) were proved. On the other hand, the supplementation of feed mixtures with faba bean meal increased ($P \leq 0.05$) the values of parameters such as b* and H in both tested muscles. It could be connected with higher antioxidant (lutein, zeaxantin, tocopherols) amount in muscles (Dal Bosco et al. 2013). The lack of the influence of faba bean on the parameters of the L* and a* colour in the *longissimus* muscles was confirmed by Gatta et al. (2013) as well as Milczarek and Osek (2014a, 2016).

Another crucial element to evaluate meat quality in fatteners' tissues is the analysis of water holding capacity (WHC) and drip loss (WN) during the meat storage. The *longissimus lumborum* muscles in pigs fed mixtures with faba bean were characterized by significantly better water holding capacity ($P \leq 0.01$) and more desirable values of drip loss measured at 48 and 72 h *post mortem*, compared to the control group.

The results of drip loss proved in the present research showed high quality of

TABLE 2. Physical characteristics of muscles

Item	Groups						*P*
	I		II		III		
	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	
Musculus longissimus lumborum							
pH_1	6.25	0.19	6.10	0.25	6.13	0.26	>0.05
pH_{24}	5.58	0.09	5.65	0.08	5.66	0.18	>0.05
Water holding capacity (%)	21.75A	3.88	19.64B	2.77	19.67B	3.88	≤0.01
Drip loss after 48 h (%)	1.96	0.33	1.70	0.29	1.78	0.30	>0.05
Drip loss after 72 h (%)	3.07	0.51	2.71	0.32	2.97	0.48	>0.05
L*	49.06	1.84	46.87	0.98	49.43	3.41	>0.05
a*	6.73	0.62	7.16	0.99	7.01	0.93	>0.05
b*	2.03a	0.60	3.04b	0.76	2.42ab	0.47	≤0.05
$C = [(a^*)^2 + (b^*)^2]^{0.5}$	7.03	0.48	7.77	1.02	7.42	0.90	>0.05
$H = b^*/a^*$	0.30	0.12	0.42	0.11	0.35	0.08	>0.05
Musculus semimembranosus							
L*	45.34	1.28	42.35	2.70	44.44	3.74	>0.05
a*	9.40	0.54	9.64	0.59	9.50	1.56	>0.05
b*	1.82a	0.47	3.46ab	1.32	2.41b	0.65	≤0.05
$C = [(a^*)^2 + (b^*)^2]^{0.5}$	9.57	0.50	10.24	0.90	9.80	1.63	>0.05
$H = b^*/a^*$	0.19a	0.13	0.36b	0.12	0.25ab	0.05	≤0.05

A, B or a, b – means within the same rows with different letter differ significantly $P \leq 0.01$ or $P \leq 0.05$.
L* – lightness of colour, a* – redness, b* – yellowness, C – chroma index, H – hue of colour.

the meat, since Joo et al. (1999) stated that drip loss in meat of the highest quality amounted to less than 6.0%, whereas Bertram et al. (2000) suggested more rigorous classification, in which the drip loss amounted to less or equal 4.0%. Gatta et al. (2013) as well as Milczarek and Osek (2014a, 2016) did not prove any significant effects of applying mixtures with low-tannin faba bean on water holding capacity. According to Jennen et al. (2007), worse values of WHC parameters during the meat processing were associated with large financial loss (due to the decrease in the meat weight), worse dietetic value of meat, lower consumer acceptance (limited possibility to sell it as culinary meat), as well as worse properties and technological yield of the meat.

The contents of basic nutrients (protein, fat and minerals) determine the nutritive value of meat. No significant effects of feeding on the nutrient content in both tested muscles were found in the present studies (Table 3).

Moreover, the previous research by Gatta et al. (2013), as well as Milczarek

TABLE 3. Basal nutrients (g/100 g) of muscles

Item	Groups						*P*
	I		II		III		
	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	
Musculus longissimus lumborum							
Dry matter	26.62	0.37	26.57	0.28	26.48	0.56	>0.05
Crude ash	1.11	0.02	1.09	0.03	1.12	0.05	>0.05
Crude protein	22.99	0.33	22.89	0.35	22.81	0.43	>0.05
Crude fat	2.60	0.23	2.55	0.18	2.45	0.17	>0.05
Musculus semimembranosus							
Dry matter	26.83	0.54	26.65	0.69	26.52	0.65	>0.05
Crude ash	1.11	0.04	1.09	0.03	1.10	0.04	>0.05
Crude protein	22.32	0.35	22.03	0.36	21.91	0.51	>0.05
Crude fat	3.63	0.27	3.57	0.40	3.57	0.29	>0.05

and Osek (2014b, 2016), did not show the influence of faba bean in animal mixtures on the nutrient content. The intramuscular fat content in the tested muscles was 1.35–1.67% and it can be admitted to be a recommended level, since the fat content lower than 1% decreased gustatory values of meat (Schwörer et al. 2000). According to Danish and American researchers, 2–3% of the intramuscular fat content was proved to be the optimal content that can be acceptable for consumers and also from the quality pork meat point of view (Wood et al. 1994, Przybylski et al. 2007). Such fat content positively influenced tenderness, tastiness and juiciness of meat and also decreased losses during the heat treatment (cooking, grilling). Larger content of intramuscular fat (above 3.5%), however, can cause lower acceptance by consumers due to noticeable fat deposits in the meat (Czarniecka-Skubina et al. 2007).

The dietetic value of meat also depends on the profile of fatty acids in the intermuscular fat. The supplementation of feed mixtures for fatteners with low-tannin faba bean positively modified the lipid profile in muscles (Tables 4 and 5).

The significant increase in the content of the most valuable exogenous fatty acids, i.e. linoleic acid C18:2_{n-6} and linolenic acid C18:3_{n-3}, was found. Furthermore, the ratio of PUFA n-3 to PUFA n-6 was more desirable and narrower in pigs that were fed mixtures with faba bean.

The acids mentioned above are essential for human development and to keep the body in good health, but there is often a lack of the acids in human nutrition (Williams 2000). According to WHO (2003), 5–4 : 1 is the most favourable ratio of n-6 to n-3 PUFAs in human diets. The ratio usually is much wider (Kunachowicz et al. 2005), but it is possible to improve the ratio

TABLE 4. Fatty acids profile (% of sum FA) of *Musculus longissimus lumborum*

Item	Groups						*P*
	I		II		III		
	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	
C 12:0	0.03	0.004	0.03	0.009	0.03	0.003	>0.05
C 14:0	0.84	0.08	0.73	0.13	0.77	0.07	>0.05
C 16:0	27.91^{a}	0.91	26.77^{b}	0.83	26.55^{b}	0.91	≤0.05
C 16:1	3.53^{a}	0.25	3.15^{ab}	0.52	3.00^{b}	0.15	≤0.05
C 18:0	9.69	0.34	9.74	0.65	9.88	0.66	>0.05
C 18:1	52.92	1.09	53.33	0.85	52.20	0.95	>0.05
C 18:2 $_{n-6}$	4.35^{B}	0.52	5.43^{AB}	0.64	6.59^{A}	0.52	≤0.01
C 18:3 $_{n-3}$	0.17^{Bb}	0.04	0.27^{ABa}	0.07	0.33^{Aa}	0.12	≤0.01
C 20:0	0.04	0.02	0.07	0.03	0.07	0.03	>0.05
C 20:1	0.20	0.007	0.21	0.04	0.19	0.03	>0.05
C 20:2	0.04	0.01	0.04	0.004	0.05	0.005	>0.05
C 20:3 $_{n-6}$	0.02	0.03	0.01	0.005	0.02	0.007	>0.05
C 20:4 $_{n-6}$	0.13^{ab}	0.02	0.11^{b}	0.02	0.18^{a}	0.08	≤0.05
SFA	38.52	1.17	37.33	1.30	37.30	1.34	>0.05
UFA	61.36	1.16	62.54	1.31	62.55	1.34	>0.05
MUFA	56.65	1.01	56.68	0.80	55.39	0.96	>0.05
PUFA	4.71B	0.56	5.86AB	0.62	7.15^{A}	0.66	≤0.01
PUFA $_{n-6:n-3}$	26.53A	0.85	21.11B	0.63	21.01^{B}	0.73	≤0.01
DFA	71.05^{b}	0.46	72.28^{a}	0.88	72.43^{a}	0.88	≤0.05
OFA	28.75^{a}	0.95	27.49^{b}	0.92	27.32^{b}	0.93	≤0.05

A, B or a, b – means within the same rows with different letter differ significantly $P \leq 0.01$ or $P \leq 0.05$.

SFA – saturated fatty acids, UFA – unsaturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, DFA – neutral or hypocholesterolemic fatty acids = MUFA + C18:0, OFA – hypercholesterolemic fatty acids = C14:0 + C16:0.

by modifying animal diets (Milczarek and Osek 2014b). The statistically significant and favourable increase in the contents of neutral fatty acids and hypocholesterolemic acids (DFA) as well as the decrease in the content of hypercholesterolemic acids (OFA) in lipids in both tested muscles were found in fatteners after the supplementation of feed mixtures with faba bean. The increase (P >0.05) in the linoleic acid content and the PUFA content, and the decrease in the OFA content in pigs of Pulawska breed fed mixtures with 10% of low-tannin faba bean were proved by Milczarek and Osek (2014b).

TABLE 5. Fatty acids profile (% of sum FA) of *Musculus semimembranosus*

Item	Groups						*P*
	I		II		III		
	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	$\bar{x}$	±*SD*	
C 12:0	0.03	0.006	0.03	0.005	0.03	0.004	>0.05
C 14:0	0.71	0.07	0.74	0.06	0.74	0.07	>0.05
C 16:0	25.58	0.82	24.55	0.71	25.23	0.50	>0.05
C 16:1	3.74a	0.40	3.46ab	0.29	3.34b	0.15	≤0.05
C 18:0	8.14b	0.60	9.07a	0.78	8.77ab	0.49	≤0.05
C 18:1	54.53	1.34	54.18	1.10	54.09	1.09	>0.05
C 18:2 $_{n-6}$	6.35Bb	1.13	6.84Aa	1.31	6.81ABa	0.80	≤0.01
C 18:3 $_{n-3}$	0.21A	0.14	0.29B	0.12	0.26B	0.08	≤0.01
C 20:0	0.05	0.03	0.07	0.03	0.05	0.03	>0.05
C 20:1	0.18b	0.01	0.23a	0.05	0.19 ab	0.02	≤0.05
C 20:2	0.05Bc	0.007	0.07Aa	0.02	0.06ABb	0.009	≤0.01
C 20:3 $_{n-6}$	0.02	0.01	0.03	0.01	0.02	0.007	>0.05
C 20:4 $_{n-6}$	0.26	0.12	0.28	0.06	0.25	0.11	>0.05
SFA	34.50	1.02	34.46	0.79	34.82	0.83	>0.05
UFA	65.34	1.02	65.37	0.79	65.01	0.83	>0.05
MUFA	58.45	1.53	57.86	1.14	57.62	1.12	>0.05
PUFA	6.89B	1.35	7.51A	1.14	7.39A	0.95	≤0.01
PUFA $_{n-6:n-3}$	31.63A	1.27	26.85B	0.78	29.70AB	1.09	≤0.01
DFA	73.48B	0.84	74.87A	0.73	73.78A	0.54	≤0.01
OFA	26.28A	0.87	25.29B	0.74	25.97B	0.55	≤0.01

A, B or a, b, c – means within the same rows with different letter differ significantly $P \leq 0.01$ or $P \leq 0.05$.

SFA – saturated fatty acids, UFA – unsaturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, DFA – neutral or hypocholesterolemic fatty acids = MUFA + C18:0, OFA – hypercholesterolemic fatty acids = C14:0 + C16:0.

CONCLUSION

The research showed that low-tannin faba bean up to 10% in grower and 20% finisher mixtures can be recommended as a partial substitution of extracted soybean meal for slow growing pigs due to the fact that the faba bean meal decreased carcass fatness, increased meatiness and improved water holding capacity. As far as human feeding is concerned, mixtures with low-tannin faba bean meal favourably increased the content of essential unsaturated fatty acids and decreased the

content of hypercholesterolemic acids in the lipid profile in the *longissimus lumborum* and *semimembranosus* muscles of pigs.

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Streszczenie: *Jakość mięsa świń żywionych mieszankami z niskotaninowym bobikiem.* Celem badań była ocena wartości rzeźnej i jakości mięsa (*musculus longissimus lumborum*, *musculus semimembranosus*) świń żywionych mieszankami z bobikiem. Badaniami objęto 48 tuczników pochodzących z trzech grup żywieniowych. Świnie grupy I żywiono mieszankami zawierającymi śrutę poekstrakcyjną sojową jako jedyny surowiec wysokobiałkowy, a tuczniki grup II i III otrzymywały mieszanki grower/finiszer z 5/10% lub 10/20% udziałem bobiku niskotaninowego. Wykazano, że wprowadzenie bobiku do mieszanek dla tuczników zwiększyło ich mięsność i powierzchnię „oka" polędwicy oraz zmniejszyło otłuszczenie tusz. Ponadto mięśnie świń grup II i III zawierały więcej niezbędnych nienasyconych kwasów tłuszczowych ($C18:2_{n-6}$, $C18:3_{n-3}$). Istotnie ($P \leq 0{,}01$) lepszym wskaźnikiem wodochłonności (WHC) cechował się *musculus longissimus lumborum* świń żywionych mieszankami z bobikiem.

Słowa kluczowe: bobik, wartość rzeźna, wieprzowina, właściwości fizyczne, skład chemiczny

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