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Meat quality of fattening pigs fed yellow lupin-based diets

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Abstract: *Meat quality of fattening pigs fed yellow lupin-based diets*. The 30 crossbred pigs [(Landrace × Yorkshire) × Duroc] were fattened in three-phase fattening period. In their nutrition as a source of protein was used soybean meal (Group C) or soybean meal and seeds of yellow lupine in the amount of 7.5% (Group E1) and 15% (Group E2). After achieving body weight of about 117.5 kg animals were slaughtered. The samples of *musculus longissimus lumborum* collected from all slaughtered pigs. Significant differences were found in drip loss percentage between groups C and E1 ($P \leq 0.05$). As regards the fatty acids, there were lower proportions of C18:2 in group E1 vs C ($P \leq 0.05$) and of C18:2 and C20:4 in group E2 vs C ($P \leq 0.01$). Differences in PUFA percentage, PUFA/SFA ratio, and proportion of n-6 fatty acids were significant, with lower values of the traits in group E1 vs C ($P \leq 0.05$) and in group E2 vs C ($P \leq 0.01$), which shows that the dietetic value of pork has slightly deteriorated. The chemical composition and the physical parameters of the meat samples were normal and at a similar level in all the groups.

Key words: fattening pigs, feeding, yellow lupin, meat quality

INTRODUCTION

Production results as well as the quality of raw materials and products are subject to thorough analysis as part of the field-to-fork programmes. These also account for the nutrition, quantity and quality of compound feeds for animals, and the acquisition of feed materials for their production. For years studies have been conducted and attempts have been made to replace soybean meal with legume seeds in livestock production (Roth-Maier et al. 2004, Froidmont et al. 2005, Pisařiková et al. 2008, Płazak et al. 2012, Kasprowicz-Potocka et al. 2014). The results obtained are thoroughly evaluated and analysed. Feeds with legume seeds are used to investigate the growth and slaughter parameters of monogastric animals (Zralý et al. 2006, 2007, Płazak et al. 2012, Sońta et al. 2015, 2016) and the qualitative parameters of the slaughter material obtained and the products made (Zralý et al. 2006, 2007, Kim et al. 2011, Mordenti et al. 2012, Hanczakowska and Świątkiewicz 2014, Milczarek and Osek 2014, Sirtori et al. 2015). The results of the studies cited above and many other experiments have confirmed the nutritional suitability of legumes for pigs. The analyses of economic efficiency are the final stage of research concerning the utility of legumes for production. The studies performed by Sońta et al.

(2015, 2016) have confirmed the appropriateness of using legumes in live pig production.

Advances in breeding, the new quality of the produced plant material, and the implementation of novel processing technologies for legume seeds have advantageously affected the value and nutritional suitability of different legume species and varieties. There have also been changes in the breeding and productive value of animals. In view of the above, and after analysing various opinions concerning the nutritional suitability of legumes in the feeding of monogastric animals, the present study was undertaken to determine the effect of partial replacement of soybean meal with yellow lupin meal in growing pig diets on pork quality.

MATERIAL AND METHODS

Thirty crossbred weaners, gilts and barrows [♀ (Landrace × Yorkshire) × × ♂ Duroc] were fattened from 27.2 to 117.5 kg of body weight. Animals were divided into three groups: control C and experimental E1 and E2 (each having 10 animals, 1 : 1 sex ratio) and placed in pens (10 animals per pen) under uniform conditions (Regulation of the Ministry of Agriculture and Rural Development of 15 February 2010). During three fattening stages, animals were fed *ad libitum* complete diets with constant access to water, as described in Sońta et al. (2016). In the control group, protein was provided by soybean meal, and in the experimental groups E1 and E2 by yellow lupin (7.5 and 15%, respectively), which partially replaced soybean meal. At the end of fattening (approx. 117.5 kg of body weight), animals were slaughtered and after 24-hour chilling of the carcasses at 4°C, a muscle sample (approx. 0.5 kg) was collected from the right half-carcasses for quality analysis. Ground samples of meat from *musculus longissimus lumborum* were analysed for the content of water, protein, fat and collagen (PN-A-82109:2010) using a Food--Scan Lab meat analyser (Foss). Fatty acid profile was determined. Fatty acid methylation was performed according to the trans esterification method EN-ISO 5509:2000). Identification of individual fatty acids in crude fat was conducted using an Agilent 7890A GC (Agilent, Waldbronn, Germany) with flame–ionization detector (FID), HP Chem software and Varian Select FAME column (100 m length, 0.25 mm diameter, 0.25 µm film thickness; Varian/Agilent Technologies, Waldbronn, Germany). The separation was performed at pre-programmed temperature: 130°C for 1 min; 130–170°C at 6.5°C/min; 170–215°C at 2.75°C/min; 215°C for 12 min, 215–230°C at 20°C/min and 230°C for 3 min. Each peak was identified using pure methyl ester standards: PUFA 1, Lot LB 75066; PUFA 2, Lot LB 83491; FAME Mix RM-6, Lot LB 68242; Supelco 37 Comp. FAME Mix, Lot LB 68887 (Supelco, Bellefonte, PA, USA). The following fatty acids were determined in the profile: C14:0 – myristic acid, C16:0 – palmitic acid, C16:1 – palmitoleic acid, C18:0 – stearic acid, C18:1 – oleic acid, C18:2 – linoleic acid, C18:3 – linolenic acid, C20:4 – arachidonic acid, C20:5 – eicosapentaenoic acid, C22:4 – docosatetraenoic acid, as well as SFA, MUFA, PUFA, n-3 and n-6. The atherogenic index (AI) and the thrombogenic

index (TI) were calculated according to Ulbricht and Southgate (1991):

$$IA = (4 \times C14:0 + C16:0 + C18:0) / / (MUFA + PUFA)$$

$$IT = (C14:0 + C16:0 + C18:0) / / (0.5 \times MUFA + 0.5 \times n\text{-}6\ PUFA + + 3 \times n\text{-}3PUFA + n\text{-}3/n\text{-}6\ PUFA)$$

Meat colour parameters were measured in the CIE L*a*b* space with a Chroma Meter CR-400/410 colorimeter (Konica Minolta). The meat colour determination procedure consisted of taking an approx. 2-cm muscle slice and making the measurements at 3 points (the result was averaged). Hue (b*/a*) and chroma [$\sqrt{(a^{*2} + b^{*2})}$] were calculated according to Mordenti et al. (2012).

In order to determine drip loss, an approx. 300 g sample of meat was placed in a polyethylene bag and kept under cold storage conditions (4°C) for 24 h. After this time, the exudate was poured off and its amount was expressed as a percent of the sample weight.

Water holding capacity was determined using the method described by Grau and Hamm (1952) as modified by Pohja and Ninivaara (1957).

Shear force was measured with a Zwick 1120 (Germany) tensiometer equipped with a Warner–Bratzler blade. The samples of meat (approx. 150 g) were roasted at 180°C until the internal temperature reached 76°C in the geometrical center of the sample. The samples were cooled at room temperature (18–22°C) and placed into a cold storage room (4°C). Three cube-shaped samples (20 × 20 × 20 mm) were cut from the slice after 24 h. Determinations were made transversely across the muscle fibres until the sample was cut completely. The maximum force needed to shear the sample was taken as the shear force value. A crosshead speed of 30 mm/min was applied until an initial tension of 2 N was reached, and 50 mm/min was used during the test proper.

The results were statistically analysed with IBM SPSS Statistics 21 software. The normality of data distribution was verified by the Shapiro–Wilk test. Differences between the groups were tested using the Kruskal–Wallis test.

RESULTS AND DISCUSSION

No statistically significant differences were found in the main chemical components of *musculus longissimus lumborum* (MLL) samples from pigs in groups C, E1 and E2 (Table 1). Hue and chroma were comparable. A difference of 1 percentage point ($P \leq 0.05$) was noted for drip loss (group C vs E1). Shear force was highest for the meat samples from pigs in group C, and lower by 3.62 and 9.41% in groups E1 and E2, respectively. The highest drip loss was noted for group C, with 6.55 and 6.67% lower values for groups E1 and E2, respectively.

Zralý et al. (2006, 2007), when feeding pigs with diets containing white lupin, obtained slightly higher moisture content, and lower or comparable protein content in meat samples, compared to our study. Sobotka and Antoszkiewicz (2002), who replaced soybean meal in pig diets with field bean, peas and rapeseed meal, also observed higher moisture content and lower protein content of the meat. Milczarek and Osek (2014), when using field bean and DDGS as a replace-

TABLE 1. Chemical and physical parameters of *musculus longissimus lumborum*

Item	Groups						*P*
	control		experimental 1		experimental 2		
	AVG	*SE*	*AVG*	*SE*	*AVG*	*SE*	
Content of the main chemical components (%)							
Water	71.78	0.24	71.51	0.20	71.43	0.29	0.470
Protein	23.23	0.11	23.38	0.13	23.05	0.10	0.159
Fat	3.81	0.22	3.54	0.24	3.83	0.31	0.788
Collagen	0.97	0.06	0.84	0.07	0.83	0.06	0.196
Physical properties							
CIE colour coordinates							
L*	51.49	0.94	52.29	0.53	51.71	0.86	0.816
a*	7.71	0.49	7.38	0.24	7.74	0.36	0.628
b*	5.12	0.33	5.13	0.25	5.12	0.16	0.993
Hue	0.66	0.03	0.70	0.04	0.66	0.04	0.545
Chroma	5.07	0.16	5.00	0.08	5.07	0.08	0.668
WHC (cm^2/g)	16.95	1.02	15.84	0.97	15.82	1.07	0.712
Drip loss (%)	1.23[a]	0.27	2.23[a]	0.34	2.10	0.92	0.040
Shear force (N)	92.30	8.29	88.96	13.94	83.61	12.23	0.709

a, a – means in rows with the same small letters differ significantly at $P \leq 0.05$.

ment, found slightly higher protein and lower fat content in MLL and in ham compared to the control group. Mordenti et al. (2012) reported no negative effect of removing soybean meal from pig diets on hue and chroma compared to the control group. Sirtori et al. (2015) showed lower hue values for samples of *musculus longissimus lumborum* muscle in the groups supplemented with peas or vetch in comparison with the control group (by 14.71 and 20.59%, respectively). The same authors obtained similar results for chroma, which suggests that it is appropriate to study the above physical parameters of meat when feeding pigs with diets containing vegetable protein replacers of soybean meal. In our study, the colour coordinates, hue and chroma were at a similar level regardless of the group.

Statistically significant differences were only found for C18:2, C20:4 and PUFA, for the PUFA/SFA ratio, and for n-6 fatty acids (Table 2).

Froidmont et al. (2005) studied the fatty acid content of muscle tissue and backfat from pigs fed diets in which soybean meal or white lupin, also supplemented with α-galactosidase, served as protein source. When comparing the content of fatty acids between the groups for both studied tissues, the authors observed many more significant differences for backfat. In the muscle tissue of the pigs fed the white lupin diet, they

TABLE 2. Fatty acid profile (%) of *musculus longissimus lumborum*

Item	Groups						*P*
	control		experimental 1		experimental 2		
	AVG	*SE*	*AVG*	*SE*	*AVG*	*SE*	
C14:0	1.25	0.02	1.32	0.04	1.34	0.03	0.199
C16:0	25.10	0.32	25.81	0.21	26.13	0.26	0.106
C16:1	3.95	0.14	3.79	0.09	3.87	0.13	0.558
C18:0	12.26	0.28	12.51	0.08	12.67	0.36	0.531
C18:1	47.41	0.45	48.38	0.36	48.40	0.61	0.286
C18:2	8.86^{Aa}	0.54	7.07^{a}	0.27	6.48^{A}	0.22	0.001
C18:3	0.29	0.08	0.19	0.01	0.17	0.01	0.335
C20:4	0.47^{A}	0.02	0.54	0.02	0.58^{A}	0.01	0.003
C20:5	0.08	0.01	0.11	0.01	0.09	0.01	0.064
C22:4	0.22	0.03	0.29	0.03	0.27	0.03	0.173
SFA	38.82	0.50	39.65	0.24	40.13	0.61	0.263
MUFA	51.36	0.42	52.17	0.33	52.27	0.58	0.269
PUFA	9.92^{Aa}	0.59	8.21^{a}	0.29	7.60^{A}	0.22	0.002
PUFA/SFA	0.26^{Aa}	0.02	0.21^{a}	0.01	0.19^{A}	0.01	0.002
n-6	9.55^{Aa}	0.52	7.90^{a}	0.27	7.33^{A}	0.21	0.001
n-3	0.37	0.07	0.31	0.02	0.27	0.02	0.322
n-6/n-3	30.48	3.14	26.06	1.14	27.79	1.31	0.275
IA	0.69	0.01	0.72	0.01	0.74	0.02	0.174
IT	1.22	0.03	1.28	0.01	1.31	0.03	0.219

a, a – means in rows with the same small letters differ significantly at $P \leq 0.05$, A, A – means in rows with the same capital letters differ significantly at $P \leq 0.01$.

found a lower proportion of SFA and PUFA, and a higher MUFA proportion. In our study, the direction of change for PUFA and MUFA was similar. In the study by the researchers cited above (Froidmont et al. 2005), the PUFA/SFA ratio was more favourable in the control groups, while the n-6 to n-3 fatty acids ratio was lowest in samples of meat from pigs fed the lupin-based diet. A similar direction of change was observed in our study. Zralý et al. (2007) found a higher proportion of saturated fatty acids in the meat of pigs receiving a white lupin diet (experimental group), and a higher percentage of mono- and polyunsaturated fatty acids in the control group. Our results for SFA and PUFA were similar to the findings of Zralý et al. (2007). Values of AI and TI did not differ among the groups (Table 2) and were comparable to those reported by Okrouhlá et al. (2013). These authors hold that for both meat and the meat product, the AI and TI

values can be modified be dietary means. The authors who fed broiler chickens (Laudadio et al. 2012) and young slaughter cattle (Cutrignelli et al. 2008, Vicenti et al. 2009) with different protein feed materials, including soybean meal, peas, white lupin and field bean, found no fundamental differences in the IA and IT values.

CONCLUSION

Partial replacement of soybean meal with yellow lupin meal had no effect on chemical and physical parameters of *musculus longissimus lumborum*, but caused a slight deterioration in the dietetic value of pork.

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Streszczenie: *Jakość mięsa tuczników żywionych mieszankami z udziałem łubinu żółtego*. Przeprowadzono trójfazowy tucz 30 świń mieszańców [(Landrace × Yorkshire) × Duroc]. W ich żywieniu stosowano jako źródło białka poekstrakcyjną śrutę sojową (grupa C) lub poekstrakcyjną śrutę sojową i nasiona łubinu żółtego w ilości 7,5% (grupa E1) i 15% (grupa E2). Po osiągnięciu masy ciała ok. 117,5 kg zwierzęta ubito. Od wszystkich tuczników pobrano po uboju próby *musculus longissimus lumborum*. Różnice istotne odnotowano w procencie wycieku swobodnego między grupami C i E1 ($P \leq 0,05$). W profilu kwasów tłuszczowych stwierdzono: mniejszy udział kwasu C18:2 w grupie E1 względem C ($P \leq 0,05$) oraz C18:2 i C20:4 w grupie E2 względem C ($P \leq 0,01$). Różnice w udziale PUFA, stosunku PUFA/SFA i udziale kwasów z grupy n-6 potwierdzono statystycznie; wartości cech były mniejsze w grupie E1 względem C ($P \leq 0,05$) oraz E2 względem C ($P \leq 0,01$), co świadczy o nieznacznym pogorszeniu wartości dietetycznej wieprzowiny. Skład chemiczny oraz parametry fizyczne prób mięsa były prawidłowe i na podobnym poziomie we wszystkich grupach.

Słowa kluczowe: tuczniki, żywienie, łubin żółty, jakość mięsa

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