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MEAT QUALITY OF BROILER CHICKENS FED MIXTURES WITH VARIED LEVELS AND VARIETIES OF FABA BEAN

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Abstract. The material were leg muscles collected from 40 broiler chickens from 5 feeding groups (I, II, III, IV and V). The differentiating factor of the groups were the seeds of faba bean added to starter/grower feed, according to the following design: group I (control) – without faba beans, group II – 8/15% high-tannin faba beans, group III – 16/22% high-tannin faba beans, group IV – 8/15% low-tannin faba beans, group V – 16/22% low-tannin faba beans addition. It was found that the addition of high- or low-tannin faba beans to compound broiler feeds did not affect the basic composition of leg muscles. More linoleic acid, C18:2(n-6), and linolenic acid, C18:3(n-3), as well as total polyunsaturated fatty acids (PUFAs), were found in the muscles of chickens fed on faba beans mixes, however, the difference was significant ($P \leq 0.05$) only between the muscles of group III and control birds. In the lipids of the treated chickens, the proportion of saturated fatty acids (SFAs) decreased significantly ($P \leq 0.01$). Significantly lower ($P \leq 0.01$) atherogenic index (AI) and thrombogenic index (TI) were found in leg muscles of faba bean treated chicken, particularly with its higher feed content. Moreover, a high content of faba beans in the feed had a positive effect on the sensory qualities.

Key words: faba beans, broiler chickens, leg muscles, chemical composition, physical properties, taste qualities

INTRODUCTION

Poultry meat is one of the most popular meat products [Puvača et al. 2014, Rocznik Statystyczny Rolnictwa 2015], thanks to its dietetic values and a great

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number of culinary applications, supported by its outstanding physical and chemical properties and sensory value. Poultry meat qualities depend on a range of genetic and environmental factors, including farm feeding. Appropriate selection of feed components for broiler chickens allows attaining a high quality of the product, including health benefits [Osek et al. 2013a].

A range of studies have been carried out lately [Moschini et al. 2005, Perella et al. 2009, Laudadio et al. 2011, Dal Bosco et al. 2013, Osek et al. 2013, Koivunen et al. 2014, Usayran et al. 2014] on leguminous plants applicability as a partial substitute for soybean extraction meal in broiler chicken feeds. The results of these experiments confirm the usefulness of faba beans as a feed component for poultry, although the data may vary greatly. Some results [Laudadio et al. 2011, Tufarelli and Laudadio 2015] indicate that replacing soybean extraction meal with high-tannin faba beans has a positive effect on the dietetic value of the meat measured as a content of polyunsaturated fatty acids (PUFAs), whereas data reported by Dal Bosco et al. [2013] say something opposite. PUFAs belong to deficient components of a human diet, and qualitatively modified poultry meat might become one of their dietary sources [Laudadio et al. 2012]. Krauss et al. [2001] and Russo [2009] emphasize that PUFAs are bioactive components which reduce the risk of cardiovascular system diseases.

The literature lacks reports on a comparison of meat quality, leg meat in particular, of broiler chickens fed feeds containing different varieties of high- and low-tannin faba beans. Hence this study, which aimed at evaluation of physicochemical and sensory properties of leg muscle meat of broiler chickens fed mixtures containing a varied level and different varieties of faba beans.

MATERIAL AND METHODS

Leg muscles were collected from 40 broiler chickens divided into 5 groups (I, II, III, IV, V). Chickens were raised for 35 days and fed starter (1–21 days) and grower feeds (22–35 days), composed of maize middlings, post-extraction soybean meal, rapeseed oil and amino-acid, mineral and vitamin additives (Table 1).

The differentiating factor between groups were faba bean introduced into the starter/grower feeds, according to the following design: group I (control) – without faba beans, group II – 8/15% high-tannin faba beans, group III – 16/22% high-tannin faba beans, group IV – 8/15% low-tannin faba beans, group V – 16/22% low-tannin faba beans. The nutritional value of the feeds were calculated according to the poultry nutrition guidelines [NŻD 2005], so as to obtain isoenergetic and isoprotein feeds.

On the completion of the trial, 8 chickens were selected from each group (each group had 32 birds) with a body weight similar to the group average. After

Table 1. Feed ingredients of the feed mixtures

Tabela 1. Skład surowcowy mieszanek paszowych

Surowce paszowe, % Feed ingredient, %	Starter			Grower		
	I	*II and IV *II i IV	III and V III i V	I	*II and IV *II i IV	III and V III i V
Maize – Kukurydza	49.92	44.59	39.37	55.285	45.245	41.22
Faba bean – Bobik	–	8.00	16.00	–	15.00	22.00
Soybean meal – Śruta poekstrakcyjna sojowa	41.50	38.00	34.50	36.00	29.50	26.00
Rapeseed oil – Olej rzepakowy	4.70	5.50	6.20	5.00	6.50	7.00
**Amino acids-mineral-vitamin additives **Dodatki aminokwasowo-mineralno-witaminowe	3.88	3.91	3.93	3.715	3.755	3.78
Total – Razem	100.00	100.00	100.00	100.00	100.00	100.00

* II and IV – high-tannin faba bean – bobik wysokotaninowy, III and V – low-tannin faba bean – bobik niskotaninowy.
** L-lysine – L-lizyna, DL-methionine – DL-metionina, limestone – kreda pastewna, monocalcium phosphate – fosforan jednowapniowy, salt – sól pastewna, premix Starter/Grower – premiks Starter/Grower.

slaughter, the muscles of the left leg (thigh and drumstick) were collected for physical and chemical analyses, and the right thigh for sensory analysis.

Basic composition (dry matter, raw ash, raw protein and raw fat) was evaluated according to AOAC [2005]. Fatty acids of the meat were profiled by gas chromatography of methyl esters, using a gas chromatograph equipped with a flame ionization detector (air-hydrogen). Based on the percentage (% of the total) of fatty acids, we calculated the atherogenic (AI) and thrombogenic (TI) indexes, as well as the hypocholesterolemic-to-hypercholesterolemic fatty acids ratio (HH) according to Ulbricht and Southgate [1991] and Santos-Silva et al. [2002]:

$$AI = (C12 : 0 + 4 \times C14 : 0 + C16 : 0) /[\Sigma MUFA + \Sigma(n–6) + \Sigma(n–3)]$$

$$TI = (C14 : 0 + C16 : 0 + C18 : 0) /[0.5 \times \Sigma MUFA + 0.5 \times \Sigma(n–6) + 3 \times \Sigma(n–3) + \Sigma(n–3) /\Sigma(n–6)]$$

$$HH = [(C18 : 1n – 9 + C18 : 2n – 6 + C20 : 4n – 6 + C18 : 3n – 3 + C20 : 5n – 3 + C22 : 5n –3 + C22 : 6 – n)/(C14 : 0 + C16 : 0)].$$

Using the Mettler Toledo pH-meter (with a spear knife probe electrode), pH measurements were carried out in the thigh muscles (m. iliotibialis) within 15 minutes and 24 hours post-slaughter. We determined water-holding capacity (WHC) by the method of Grau and Hamm [1953] modified by Pohja and Ninivaara [1957]. Also, meat colour appraisal was carried out using a tristimulus colorimeter (Minolta). The L*a*b* coordinates system was used to evaluated the colour. The a*b* colour coordinates were used to calculate the chroma (C) and hue (H) of the colour [Mordenti et al. 2012, Milczarek and Osek 2016].

Sensory evaluation of the muscle meat was performed after thermal treatment, according to a 5-point scale: 1 (the lowest score) through 5 (the highest score). Muscles were heated in 0.8% NaCl water solution (with a 1 : 2 meat-to-water proportion) until attaining 80°C in the geometric center of the sample. The assessment was carried out by a panel of 8 qualified subjects. The samples were evaluated for flavour, tenderness, juiciness and palatability [Baryłko-Pikielna and Matuszewska 2014].

The results were processed statistically using one-way ANOVA. The significance of differences between means in groups was estimated by means of Tukey's test.

RESULTS AND DISCUSSION

Introduction of different varieties of faba beans in the proportions 8/15% and 16/22% in starter/grower feeds for broiler chickens did not affect the contents of the basic components in the studied leg muscles (Fig. 1).

Similarly, Osek et al. [2003] and Laudadio et al. [2011] did not observe differences in basic component contents in leg muscles of chickens fed diet containing faba beans. More ash ($P \leq 0.01$), as well as less dry matter and crude fat ($P \leq 0.05$) in birds fed starter/grower containing 13.5/19.5% of high-tannin faba beans were reported by Osek et al. [2013]. Lower fat contents ($P \leq 0.05$) in leg muscles of chickens receiving faba bean containing diet were found by Meluzzi et al. [2009] and Dal Bosco et al. [2013].

The use faba beans in the diet of chickens modified the muscle fatty acid profile in a health-enhancing direction (Table 2).

More linoleic acid, C18 : 2 (n–6), and linolenic acid, C18 : 3 (n–3) and – in consequence – more PUFAs were found in leg muscles of faba bean fed chickens. However, a significant difference ($P \leq 0.05$) in relation to the control was found only if high-tannin faba beans had been added to the feed (group II). An increased level of C18 : 2 (n–6) and C18 : 3 (n–3) in the muscles of birds after faba bean addition to feed was also observed by Tufarelli and Laudadio [2015]. Osek et al. [2003] and Laudadio et al. [2011] claim that feeding poultry with faba bean diets does not significantly influence FA profiles in their muscles, whereas Dal Bosco et al. [2013] demonstrated a significant ($P \leq 0.05$) reduction in PUFAs content.

The studies revealed a significant ($P \leq 0.01$) reduction in saturated fatty acids (SFAs), including palmitic acid (C16 : 0, a hypercholesterolemic acid) in the muscles of the treated chickens, as compared to the control. In the lipids of these birds, there were less ($P \leq 0.01$) hypercholesterolemic acids (OFAs) and more natural, hypocholesterolemic fatty acids (DFAs). Tufarelli and Laudadio [2015] also found a significant decrease in SFAs, including palmitic acid, and an incre-

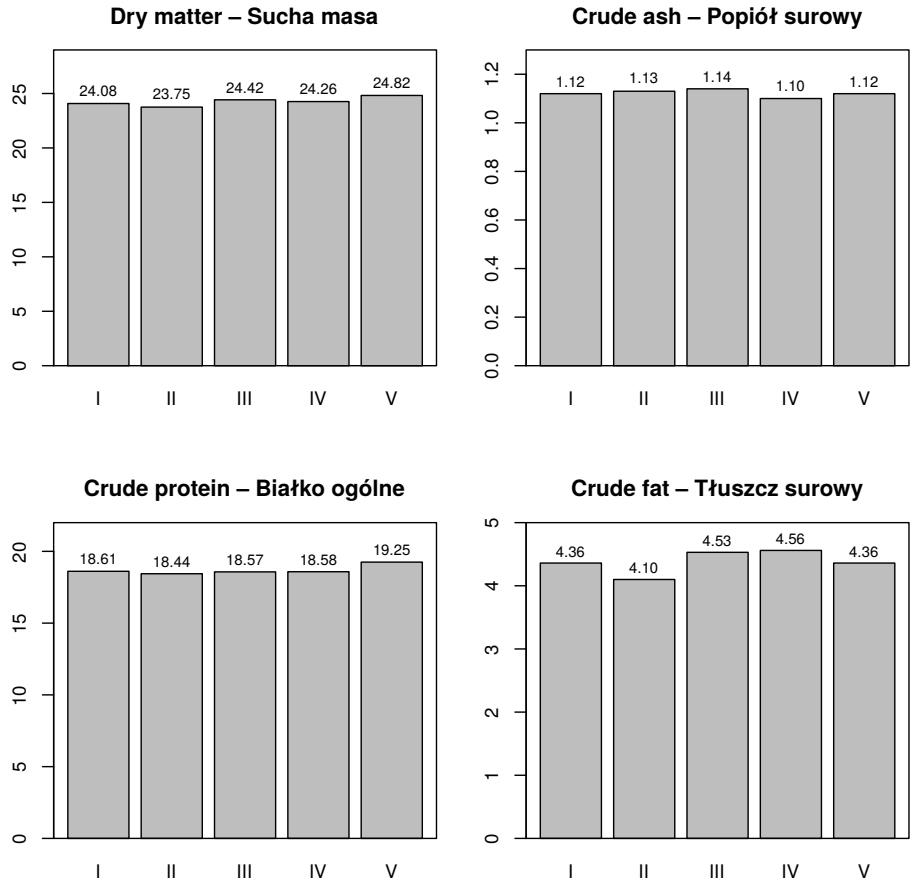

Fig. 1. Basal nutrients content in leg muscles, %

Rys. 1. Zawartość składników podstawowych w mięśniach nóg, %

ased ($P \leq 0.05$) hypercholesterolemic-to-hypocholesterolemic acids ratio (HH) in the meat of chickens fed on feeds with faba beans.

A positive effect of high- and low-tannin faba bean middlings added to mixes for broiler chickens has been confirmed significantly ($P \leq 0.01$) by lower atherogenic and thrombogenic indexes in the analyzed muscles. Laudadio et al. [2011] found no effect ($P > 0.05$) of faba bean feeds in AI and TI indexes for chicken leg muscles.

The quality of meat is also shaped by its physical properties, such as acidity, water-holding capacity, and colour (Table 3).

Adding faba beans (irrespective of its variety) to the chicken feeds did not affect the acidity (pH_1 and pH_{24}) of *musculus iliotibialis*. However, after 24-hour cooling period, the concentration of hydrogen ions in the analyzed sampled of meat unexpectedly dropped, which may demonstrate a different process of its maturation resulting from the function and structure of the muscles and fat content. Other authors [Laudadio et al. 2011, Dal Bosco et al. 2013, Osek et al. 2013, Tufarelli and Laudadio 2015] also failed to demonstrate an effect of faba bean on the pH of broiler chickens meat.

Table 2. Fatty acids profile (% of sum FA) of leg muscles

Tabela 2. Profil kwasów tłuszczowych (% sumy KT) mięśni nóg

Fatty acids Kwasy tłuszczowe	Groups – Grupy					SEM
	I	II	III	IV	V	
C 14:0	0.13 Aa	0.11 Aab	0.11 Aab	0.11 Aab	0.07 Bc	0.0001
C 16:0	13.77 A	10.95 B	10.37 B	11.01 B	10.26 B	0.239
C 16:1	2.47 Aa	1.70 Bbc	1.63 Bbc	1.84 Bb	1.38 Bc	0.291
C 18:0	2.89 A	2.90 A	2.88 A	2.75 A	2.06 B	0.155
C 18:1	53.40 Dd	54.68 Dcd	56.24 Bb	55.48 BCbc	57.80 Aa	0.252
C 18:2 n–6	22.83 b	24.19 a	23.20 ab	23.23 ab	23.43 ab	0.331
C 18:3 n–3	3.56 c	4.18 ab	4.22 a	4.27 a	3.84 bc	0.035
C 20:0	0.02 Bc	0.17 Aab	0.24 Aa	0.15 ABab	0.13 Bbc	0.025
C 20:1	0.24	0.36	0.34	0.33	0.27	0.005
C 20:2	0.04	0.04	0.04	0.05	0.05	0.0005
C 20:3	0.04	0.05	0.05	0.04	0.06	0.0001
C 20:4 n–6	0.38	0.45	0.42	0.47	0.39	0.006
C 22:0	0.02	0.02	0.02	0.03	0.02	0.0008
Σ SFA	16.84 Aa	14.15 Bb	13.63 BCbc	14.04 BCb	12.57 Cc	0.300
Σ UFA	82.95 Cc	85.64 Bb	86.15 ABab	85.71 ABb	87.16 Aa	0.279
Σ MUFA	56.11 Dd	56.75 CDcd	58.22 ABb	57.65 BCbc	59.47 Aa	0.261
Σ PUFA	26.85 b	28.90 a	27.93 ab	28.07 ab	27.69 ab	0.607
Σ PUFA n6:n3	6.52 A	5.91 BC	5.60 C	5.55 C	6.34 AB	0.459
Σ DFA	85.85 B	88.55 A	89.03 A	88.46 A	89.22 A	0.257
Σ OFA	13.90 A	11.06 B	10.48 B	11.12 B	10.33 B	0.244
S/P	0.202 A	0.163 B	0.155 CB	0.161 B	0.142 C	0.0001
AI	0.172 A	0.133 B	0.125 B	0.133 B	0.121 B	0.0001
TI	0.333 Aa	0.261 Bb	0.248 Bbc	0.258 Bbc	0.233 Bc	0.0002
HH	5.770 B	7.556 A	8.023 A	7.506 A	8.325 A	0.183

A, B, C, D – significant differences at $P \leq 0.01$; a, b, c, d – significant differences at $P \leq 0.05$.
A, B, C, D – różnice istotne dla $P \leq 0{,}01$; a, b, c, d – różnice istotne dla $P \leq 0{,}05$.
SFA – saturated fatty acids – nasycone kwasy tłuszczowe; UFA – unsaturated fatty acids – nienasycone kwasy tłuszczowe; MUFA – monounsaturated fatty acids – jednonienasycone kwasy tłuszczowe; PUFA – polyunsaturated fatty acids – wielonienasycone kwasy tłuszczowe; DFA= MUFA + C18:0 – neutral and hypocholesterolemic fatty acids – neutralne i hipocholesterolemiczne kwasy tłuszczowe;. OFA= C14:0 + C16:0 – hypercholesterolemic fatty acids – hipercholesterolemiczne kwasy tłuszczowe.

The trial did not reveal a significant effect of the feeds on free water in the muscles, whereas Laudadio et al. [2011] demonstrated significant ($P \leq 0.01$) deterioration of water-holding capacity in thigh muscles of chickens fed a faba bean feed, despite a lack of differences in the meat pH.

The feeding had an effect on the colour of *musculus iliotibialis* in the chickens, as measured in the chroma of b* towards yellow. Group II chickens were characterized by the lowest saturation of the b* colour, however, a significant difference was confirmed only for the group fed low-tannin faba beans (group V). There was an increasing trend in b* of the meat of faba bean fed chickens, which is consistent with the results by Laudadio et al. [2011], who demonstrated significant ($P \leq 0.05$) increase in b* as a response to 16% of faba beans in the feed. Dal Bosco et al. [2013], on the other hand, did not confirm a significant increase in colour chroma towards yellow in the muscles of chickens fed a feed containing 16% of extruded faba beans.

Table 3. Physical properties of thigh muscles

Tabela 3. Właściwosci fizyczne mięśni nóg

Item – Wyszczególnienie	Groups – Grupy					SEM
	I	II	III	IV	V	
pH_1	6.20	6.34	6.28	6.25	6.27	0.159
pH_{24}	6.31	6.30	6.44	6.30	6.38	0.190
WHC, %	11.48	8.96	10.51	10.38	9.55	4.318
L*	46.98	46.44	45.58	45.37	47.16	3.820
a*	4.77	5.02	5.76	5.06	4.72	0.642
b*	1.82 AB	1.35 B	2.70 AB	2.01 AB	3.62 A	1.318
C* = [(a*)2 + (b*)2]0.5	5.24	5.23	6.51	5.50	6.02	0.684
H* = b*/a*	0.39 AB	0.26 B	0.50 AB	0.41 AB	0.78 A	0.638

A, B – significant differences at $P \leq 0.01$; A, B – różnice istotne dla $P \leq 0{,}01$.

Table 4. Sensory evaluation thigh muscles of chickens, points

Tabela 4. Ocena organoleptyczna mięśni udowych kurcząt brojlerów, punkty

Item – Wyszczególnienie	Groups – Grupy					SEM
	I	II	III	IV	V	
Flavour, intensity – Zapach, intensywność	4.69	4.69	4.75	4.63	4.81	0.208
Flavour, desirability – Zapach, pożądalność	4.81	4.56	4.88	4.63	4.69	0.197
Juciness – Soczystość	4.38 b	4.69 ab	4.88 a	4.75 a	4.69 ab	0.171
Tenderness – Kruchość	4.56 b	4.56 b	4.94 a	4.69 ab	4.69 ab	0.154
Palatability, intensity – Smakowitość, intensywnść	4.50	4.81	4.88	4.75	4.63	0.177
Palatability, desirability – Smakowitość, pożądalność	4.69	4.81	4.88	4.63	4.69	0.190
Arithmetic mean of traits – Średnia arytmetyczna cech	4.60	4.69	4.86	4.68	4.70	0.100

a, b – significant differences at $P \leq 0.05$; a, b – różnice istotne dla $P \leq 0{,}05$.

Results of organoleptic properties evaluation of studied chicken meat are presented in Table 4. From the consumer's point of view, these are very important traits, indicative of the quality of meat.

Introduction of faba beans to chickens feeds significantly ($P \leq 0.05$) changed texture properties of the meat, i.e. tenderness and juiciness. The highest evaluation scores were granted to the meat of chickens treated with high-tannin faba beans (group III), and the difference was significant in relation to the control. The calculated mean for all the evaluated sensory traits of leg muscles proves that, regardless of faba bean varieties in the feed, its higher content positively affected the organoleptic properties of meat, which confirms the results obtained reported by Osek et al. [2003, 2013].

CONCLUSIONS

Addition of high- or low-tannin faba beans, regardless of the variety, to the feeds of broiler chickens did not affect the contents of basic components in leg muscles; however, it had a positive effect on the profile of fatty acids. Significantly ($P \leq 0.01$) lower atherogenic (AI) and thrombogenic (TI) indexes were noted in the muscles of the treatment birds. No effect of treatment has been found in relation to the physical properties of the meat, except for its higher colour saturation towards yellow. The sensory evaluation revealed that the meat of chickens fed the feeds containing faba beans achieved higher scores, the more faba beans in the diet, the higher the score for meat organoleptic properties.

The experiment leads to a recommendation that high- or low-tannin faba beans to broiler chickens diet be introduced to compound feed mixes for broiler chickens, as it improved the quality of the meat.

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JAKOŚĆ MIĘSA KURCZĄT BROJLERÓW ŻYWIONYCH MIESZANKAMI ZAWIERAJĄCYMI RÓŻNE UDZIAŁY I ODMIANY BOBIKU

Streszczenie. Materiał badawczy stanowiły mięśnie nóg pochodzące od 40 kurcząt brojlerów z 5 grup żywieniowych (I, II, III, IV, V). Czynnikiem różnicującym grupy były nasiona bobiku wprowadzone do mieszanek starter/grower, według układu: grupa I (kontrolna) – bez bobiku, grupa II – 8/15% nasion bobiku wysokotaninowego, grupa III – 16/22% nasion bobiku wysokotaninowego, grupa IV – 8/15% nasion bobiku niskotaninowego, grupa V – 16/22% nasion bobiku niskotaninowego. Wykazano, że wprowadzenie wysoko lub niskotaninowego bobiku do mieszanek dla kurcząt brojlerów nie wpłynęło na zawartość składników podstawowych w mięśniach nóg. Więcej kwasu linolowego C18 : 2(n–6) i linolenowego C18 : 3(n–3), a w sumie wielonienasyconych kwasów tłuszczowych zanotowano w mięśniach kurcząt żywionych mieszankami zawierającymi bobik z tym, że różnicę jako istotną ($P \leq 0{,}05$) statystycznie potwierdzono jedynie między mięśniami ptaków z grupy III, a kontrolnej. W lipidach mięśni kurcząt doświadczalnych zmniejszył się istotnie ($P \leq 0{,}01$) udział nasyconych kwasów tłuszczowych. Istotnie ($P \leq 0{,}01$) niższe wskaźniki aterogenny (AI) i zakrzepowy (TI) wykazano w mięśniach nóg kurcząt otrzymujących mieszanki z bobikiem, zwłaszcza z wyższym jego udziałem. Ponadto wyższy jego udział w mieszance (niezależnie od odmiany) pozytywnie zmodyfikował walory sensoryczne mięśni.

Słowa kluczowe: bobik, kurczęta brojlery, mięśnie nóg, skład chemiczny, właściwości fizyczne, walory smakowe

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