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The impact of faba bean with high or low content of tannins on the results of rearing and carcass quality of broiler chickens Part II. Meat quality of chickens

Wpływ bobiku o wysokiej lub niskiej zawartości tanin na wyniki odchowu i wartość rzeźną kurcząt brojlerów. Część II. Jakość mięsa kurcząt

Summary. The aim of the study was to evaluate breast muscles quality of broiler chickens fed mixtures with different percentage of high- or low-tannin faba bean. The material consisted of 40 muscles taken from chickens from the 5 groups. Control group chickens (I) were fed the mixtures in which the only high-protein raw material was soybean meal, and the starter/grower mixtures for experimental chickens 10/20% or 20/30% of the protein of the meal was replaced by high-tannin (II and III groups) or low-tannin faba bean (IV and V groups). It has been shown that the introduction of a higher share of faba bean (regardless of variety) to mixtures for chickens increased the intensity of the yellow colour and a chroma C ($P < 0.05$). No effects applied feeding birds on the content of the basic nutrients in muscles. Intramuscular fat of breast muscles the chickens fed with mixtures containing faba bean had lower ($P < 0.01$) SFA and more ($P < 0.05$) PUFA, but only in the muscles of the birds fed diets with a higher share of faba bean. In addition, the muscles received a higher average note for the sensory characteristics. The obtained results allow to recommend an even higher percentage of faba bean in mixtures, because it has improved the quality of breast muscles in the health-oriented direction.

Key words: broiler chickens, breast muscles, physico-chemical properties, sensory value, faba bean

INTRODUCTION

The consumer expects safety and consistent high quality food. In the case of poultry meat see it as a set of sensory characteristics, health and convenience of processing. These features are formed at all stages of production of broiler meat chicken, ranging from rearing birds, and ending with its storage. Genetic factors combined with environmental (conditions of living, nutrition), and then properly carried out the slaughter and storage in good conditions can positively affect its quality, including nutritional value. It is extremely important from the point of view of the consumer for

a broiler chicken meat has a high content of easily digestible protein and the standard value and the low energy value associated with the small amount of fat [Grześkowiak *et al.* 2011, Kunachowicz *et al.* 2014]. Among the above-mentioned components of muscle protein content remained relatively constant, while the amount of intramuscular fat and its fatty acid profile are much more variable depending on a number of factors, including the feeding [Meluzzi *et al.* 2009, Dal Bosco *et al.* 2013, Osek *et al.* 2013, Pietrzak *et al.* 2013, Usayran *et al.* 2014, Biegniewska *et al.* 2016]. Any change in the composition of the ration chickens can affect the fatty acid profile of the meat. This is very important because the average human diet characterized by the feature very small amount of unsaturated fatty acids, and 10-20 times more omega-6 acids of the omega-3, while it should not be more than 4-5 times [Simopoulos 2008, Jarosz 2012].

At the moment feeding of broiler chickens are popular legumes (including faba bean) as partial substitutes protein soybean meal [Vilariño *et al.* 2009, Crépon *et al.* 2010, Osek *et al.* 2013, Usayran *et al.* 2014, Tufarelli and Laudadio 2015, Rubio and Molina 2016]. The results of rearing and slaughter of chickens in the aforementioned experiments indicate the appropriateness of their use, but do not give a clear answer to their impact on the quality of the muscles.

The aim of the present study was to evaluate the effect of introducing different percentage of high- or low-tannin faba beans into broiler chicken mixtures on some breast muscles quality traits.

MATERIAL AND METHODS

The material consisted of 40 samples of breast muscles taken from broiler chickens from the 5 groups (I, II, III, IV, V). The birds were fed according the Poultry Nutrition Standards recommendations [Normy… 2005]. The experimental factor were faba bean seeds introduced into the starter/grower mixtures in amounts replacing 10/20% or 20/30% protein of post-extraction soybean meal according to the following scheme:

– group I (control) – no faba bean,
– group II – 8/15% of high-tannin faba bean,
– group III – 16/22% of high-tannin faba bean,
– group IV – 8/15% of low-tannin faba bean,
– group V – 16/22% of low-tannin faba bean.

On the end day of the feeding experiment, 8 birds (4 roosters and 4 hens) were selected from each group with a weight representative for a given group and gender, and then slaughtered. During simplified carcass analysis the breast muscle samples were collected to determine physico-chemical and organoleptic properties.

Breast muscle analyses

The measurements of hydrogen ion concentration (pH) in the muscle (*m. pectoralis major*) of each bird were carried out using a Testo 205 pH meter 15 minutes and 24 hours after slaughter. The second measurement were done after 24 hours chilling at temperature 0–4°C of the carcasses.

The determination of water-holding capacity (WHC) was based on the amount of loose water (expressed in %) lost by the sample of meat placed on the filter paper and

subjected to a constant pressure between the two glass plates [Grau and Hamm 1953]. The surface of released water area (cm^2) was determined using a planimeter and loose water volume was calculated assuming that 1 cm^2 of released water binds 10 mg of muscle juice absorbed by the filter paper.

The meat colour was evaluated using a trichromatic Minolta colorimeter. The L*a*b* system was used to describe the colour. In the applied measuring system, L* represented lightness, which is a spatial vector, while a* and b* are coordinates of trichromaticity, where positive values of a* correspond to the red colour, negative to green colour, positive b* values – yellow, negative b* – blue. Saturation (C) and hue (H) of the colour were calculated based on the results of a* and b* colour parameters according to equations of Mordenti *et al.* [2012] and Milczarek and Osek [2016].

The content of basic ingredients in the breast muscle was determined according to AOAC International [2011]. The fatty acid profile of the lipid fraction was determined by gas chromatography of methyl esters using a Varian 450-GC gas chromatograph equipped with a flame ionization detector (air-hydrogen). A Select ™ Biodiesel for FAME capillary column was used (30 m, 0.32 mm, 0.25 μm) with a Select Biodiesel for FAME Fused Silica filling. Injector temperature was 250°C, detector – 300°C and 200°C of the column (initial) and 240°C (final). Helium was used as a carrier gas, with a flow of 2.5 ml per minute.

Atherogenic index (AI) and thrombotic index (TI) were calculated on the basis of fatty acid percentage (% of total) according to Ulbricht and Southgate [1991]:

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

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

In addition, sensory evaluation of the muscle (after thermal treatment) was conducted using a 5-point scale: from 1 (minimum) to 5 (maximum). Muscles were heated in an aqueous solution of 0.8% NaCl (assuming the meat to water ratio of 1 : 2) to reach a temperature of 80°C at the geometric center of the sample. The evaluation was performed by a group of 8 trained people. The samples were evaluated for palatability, flavour, juiciness and tenderness [Baryłko-Pikielna and Matuszewska 2014].

The obtained results were analyzed statistically using one-way analysis of variance (ANOVA). Duncan's test was used to determine the significance of differences between mean values of the groups (StatSoft ver 12.5, 2015).

RESULT AND DISCUSSION

In the current study, there was no influence observed of the applied nutrition on important elements of the assessment of muscle quality, such as acidity (pH_1 and pH_{24}), water holding capacity, and colour L*, a*, H (tab. 1).

Introduction of faba bean to the mixtures resulted in significantly better colour intensity towards yellow (b*) and increase in its saturation (C), especially in muscles of chickens fed mixtures with a higher level of faba bean. No interaction of mixtures with faba bean on the acidity of the breast muscles was consistent with studies of Laudadio *et al.* [2011] and Osek *et al.* [2013]. Dal Bosco *et al.* [2013] reported that the introduction of 16% faba bean to the mixture significantly increased the pH of the breast muscles, but had no effect on water holding capacity and colour of meat. The values of the L* parame-

ter obtained in the study were characteristic of normal muscle, because as reported by Qiao *et al.* [2001]. L* colour lightness of the normal breast muscle is in the range of 48––53, values above 53 indicate lighter colour, and lower than 46 darker coloured muscles. A significant reduction (44.62 *vs*. 46.77) of lightness and parallel worsening ($P < 0.05$) of WHC of the breast muscles after the introduction of 31% of faba bean to the mixture for broiler chickens was shown by Laudadio *et al.* [2011].

Table 1. Physical properties of breast muscles
Tabela 1. Właściwości fizyczne mięśni piersiowych kurcząt

Specification Wyszczególnienie	Groups/ Grupy					SEM	P value Wartość P
	I	II	III	IV	V		
pH_1	6.33	6.27	6.23	6.12	6.21	0.42	0.071
pH_{24}	5.81	5.78	5.89	5.79	5.72	0.23	0.743
WHC (%)	11.54	9.68	10.93	10.87	11.95	1.95	0.655
L*	49.20	47.69	49.47	48.41	50.70	3.03	0.285
a*	2.81	3.33	2.85	3.33	3.30	0.54	0.093
b*	3.07 ^{ab}	2.81 ^{b}	4.55 ^{a}	3.05 ^{ab}	4.21 ^{a}	1.28	<0.05
$C = [(a^*)^2 + (b^*)^2]^{0.5}$	4.27 ^{b}	4.53 ^{ab}	5.54 ^{a}	4.54 ^{ab}	5.39 ^{a}	0.90	<0.05
$H = b^*/a^*$	1.16	0.92	1.75	0.92	1.31	0.61	0.053

WHC – water holding capacity/ wodochłonność
a, b – values in rows with different letters differ significantly/ wartości oznaczone w wierszach różnymi literami różnią się istotnie

The content of basic components in the breast muscles (tab. 2) did not depend on the composition of the component content of the mixtures, which confirmed the results of Laudadio *et al.* [2011]. Meluzzi *et al.* [2009], after the partial replacement of soybean post-extraction meal with faba bean meal (40% faba bean in diets) in mixtures for chickens, recorded a slight increase in protein content in the breast muscles. In turn, Dal Bosco *et al.* [2013] and Osek *et al.* [2013] demonstrated a significant reduction of the crude fat content in the muscles of chickens fed mixtures with faba bean.

Table 2. Basal nutrients content (%) of breast muscles
Tabela 2. Zawartość (%) składników podstawowych w mięśniach piersiowych

Specification Wyszczególnienie	Groups/ Grupy					SEM	P value Wartość P
	I	II	III	IV	V		
Dry matter Sucha masa	25.15	25.18	25.12	24.70	24.17	0.63	0.119
Crude ash Popiół surowy	1.22	1.22	1.19	1.23	1.20	0.03	0.326
Crude protein Białko surowe	22.73	22.94	22.61	22.35	21.79	0.69	0.063
Crude fat Tłuszcz surowy	1.21	0.99	1.42	1.11	1.20	0.69	0.132

Table 3. Fatty acids profile (% of sum) of breast muscles
Tabela 3. Profil kwasów tłuszczowych (% sumy) mięśni piersiowych

Specification Wyszczególnienie	Groups/ Grupy					SEM	P value Wartość P
	I	II	III	IV	V		
C 14:0	0.14	0.11	0.08	0.09	0.09	0.03	0.099
C 16:0	14.30 ^{A}	11.59 ^{B}	10.44 ^{B}	11.22 ^{B}	11.12 ^{B}	0.59	<0.01
C 16:1	2.14 ^{A}	1.35 ^{B}	1.28 ^{B}	1.43 ^{B}	1.38 ^{B}	0.44	<0.01
C 18:0	4.03	3.88	3.77	3.91	3.67	0.23	0.298
C 18:1	51.80 ^{B}	54.02 ^{AB}	55.96 ^{A}	55.13 ^{A}	54.67 ^{AB}	1.13	<0.01
C 18:2 $_{n-6}$	22.76 ^{b}	23.49 ^{a}	22.69 ^{b}	22.67 ^{b}	23.20 ^{ab}	0.40	<0.05
C 18:3 $_{n-3}$	3.21 ^{Bb}	3.71 ^{ABa}	3.81 ^{Aa}	3.77 ^{ABa}	4.06 ^{Aa}	0.20	<0.01
C 20:0	0.16	0.17	0.16	0.16	0.21	0.04	0.374
C 20:1	0.32	0.37	0.31	0.34	0.30	0.09	0.890
C 20:2	0.07 ^{b}	0.10 ^{ab}	0.19 ^{a}	0.10 ^{ab}	0.08 ^{ab}	0.04	<0.05
C 20:3	0.09	0.07	0.11	0.10	0.09	0.04	0.363
C 20:4 $_{n-6}$	0.74	0.86	0.90	0.83	0.86	0.63	0.817
C 22:0	0.02	0.03	0.02	0.02	0.02	0.02	0.899
Σ SFA	18.64 ^{A}	15.77 ^{B}	14.47 ^{B}	15.39 ^{B}	15.16 ^{B}	0.74	<0.01
Σ UFA	81.12 ^{B}	83.96 ^{A}	85.24 ^{A}	84.35 ^{A}	84.52 ^{A}	0.73	<0.01
Σ MUFA	54.26 ^{Bb}	55.74 ^{ABab}	57.55 ^{Aa}	56.89 ^{ABa}	56.22 ^{ABab}	1.02	<0.01
Σ PUFA	26.85 ^{b}	28.23 ^{a}	27.69 ^{ab}	27.46 ^{ab}	28.30 a	0.60	<0.05
n-6:n-3	7.10 ^{A}	6.37 ^{AB}	5.96 ^{B}	6.02 ^{B}	5.73 ^{B}	0.30	<0.01
Σ DFA	85.14 ^{B}	87.84 ^{A}	89.01 ^{A}	88.26 ^{A}	88.19 ^{A}	0.60	<0.01
Σ OFA	14.44 ^{A}	11.70 ^{B}	10.52 ^{B}	11.30 ^{B}	11.21 ^{B}	0.59	<0.01
SFA/PUFA	0.228 ^{A}	0.186 ^{B}	0.168 ^{B}	0.180 ^{B}	0.176 ^{B}	0.01	<0.01
AI	0.183 ^{A}	0.143 ^{B}	0.127 ^{B}	0.137 ^{B}	0.136 ^{B}	0.03	<0.01
TI	0.379 ^{A}	0.303 ^{B}	0.274 ^{B}	0.294 ^{B}	0.283 ^{B}	0.01	<0.01

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; AI – atherogenic index/ indeks aterogenności; TI – thrombogenic index/ indeks tombogeniczności;
A, B and a, b – values with different superscripts differ significantly at A, B – $P < 0.01$ or a, b – $P < 0.05$ in row
A, B i a, b – wartości oznaczone w wierszach różnymi literami różnią się istotnie A, B – $P < 0,01$ i a, b – $P < 0,05$

The analysis of fatty acids in the lipids of breast muscles (tab. 3) showed that significantly ($P < 0.01$) less palmitic acid (belonging to hypercholesterolemic acids – OFA) was recorded in the breast muscles of chickens fed mixtures containing faba bean (groups: II, III, IV and V). In addition, more linoleic acid was found in these muscles, and the difference between group III and V (a higher percentage of faba bean in the mixture), and the control was significant ($P < 0.01$). In consequence, introduction of faba bean to the mixtures increased ($P < 0.01$) the proportion of unsaturated fatty acids (UFA), while the most of polyunsaturated fatty acids (PUFAs) was recorded in muscle lipids of chickens feed mixtures with a lower percentage of faba bean (group II and IV) and the difference was significant compared to the control group of chickens ($P < 0.05$). Also Tufarelli and Laudadio [2015] showed that the faba bean used in the mixtures significantly reduced the

proportion of saturated fatty acids (SFA) and increased levels of polyunsaturated fatty acids (PUFA). Meluzzi *et al.* [2009] and Dal Bosco *et al.* [2013] demonstrated the opposite – an increase in SFA and reduction of PUFA in lipid profile of the breast muscles of chickens receiving a mixture with faba bean. Laudadio *et al.* [2011] reported a significant ($P < 0.05$) increase in muscle PUFA in broilers after the introduction of 31% of faba bean to the mixture. The positive impact of mixtures with faba bean on the nutritional properties of chicken meat was confirmed by significantly lower values of calculated atherogenic (AI) and thrombogenic (TI) indices. Laudadio *et al.* [2011] reported lack of effect on the above lipid indices of breast muscles, whereas in a later study of Tufarelli and Laudadio [2015], a decrease ($P < 0.05$) of the above-mentioned indices was found, but in *pectorialis major* muscle of birds.

Table 4. Sensory evaluation muscles (points)
Tabela 4. Wyniki oceny sensorycznej mięśni (pkt)

Specification Wyszczególnienie	Groups/ Grupy					SEM	P value Wartość P
	I	II	III	IV	V		
Flavour – intensity Zapach – natężenie	4.56	4.38	4.63	4.50	4.69	0.55	0.815
Flavour – desirability Zapach – pożądalność	4.44	4.75	4.88	4.69	4.56	0.51	0.497
Juciness/ Soczystość	4.06 ^{b}	4.44 ^{ab}	4.75 ^{a}	4.44 ^{ab}	4.69 ^{a}	0.44	<0.05
Tendernes/ Kruchość	4.44	4.63	4.81	4.75	4.56	0.49	0.463
Palatability – intensity Smakowitość – natężenie	4.06 ^{b}	4.56 ^{ab}	4.81 ^{a}	4.56 ^{ab}	4.70 ^{a}	0.46	<0.05
Palatability – desirability Smakowitość – pożądalność	4.44	4.75	4.88	4.63	4.56	0.45	0.367
Arithmetic averages of traits Średnia arytmetyczna cech	4.33 ^{b}	4.58 ^{ab}	4.79 ^{a}	4.59 ^{ab}	4.63 ^{a}	0.34	<0.05

a, b – values in rows with different letters differ significantly/ wartości oznaczone w wierszach różnymi literami różnią się istotnie

Organoleptic assessment of breast muscles conducted in the study showed the highest average scores for all taste characteristics and juiciness as well as palatability intensity for muscles of chickens fed mixtures with a higher percentage of faba bean, and the difference was confirmed as statistically significant ($P < 0.05$) when compared with the muscles of chickens in the control group (tab. 4). This fact should be associated with a higher content of intramuscular fat, which significantly affects the flavour as well as tenderness and juiciness of the muscle. Osek *et al.* [2013] using mixtures containing high-tannin faba bean in the nutrition of broiler chickens did not record their significant impact on the results of sensory evaluation.

CONCLUSIONS

In summary, the obtained results allow to recommend an even higher percentage of faba bean in mixtures, because it has improved the quality of breast muscles in the health-oriented direction.

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Streszczenie. Celem przeprowadzonych badań była ocena jakości mięśni piersiowych kurcząt brojlerów żywionych mieszankami z różnym udziałem bobiku wysoko lub niskotaninowego. Materiał badawczy stanowiło 40 mięśni piersiowych pobranych od kurcząt z 5 grup żywieniowych. Kurczęta z grupy kontrolnej otrzymywały mieszanki, w których jedynym surowcem wysokobiałkowym była poekstrakcyjna śruta sojowa, natomiast w mieszankach starter/grower dla kurcząt doświadczalnych 10/20% lub 20/30% białka tej śruty zastąpiono bobikiem wysokotaninowym (grupy II i III) lub niskotaninowym (grupy IV i V). Wykazano, że wprowadzenie większej ilości bobiku (niezależnie od odmiany) do mieszanek dla kurcząt zwiększyło natężenie barwy żółtej i stopień nasycenia C barwy ($P < 0,05$). Nie zanotowano wpływu zastosowanego żywienia ptaków na zawartość składników podstawowych w mięśniach. W tłuszczu śródmięśniowym IF kurcząt żywionych mieszankami z bobikiem odnotowano mniej ($P < 0,01$) SFA, natomiast więcej ($P < 0,05$) PUFA, ale tylko w mięśniach ptaków żywionych mieszankami z większym udziałem bobiku. Ponadto mięśnie tych kurcząt otrzymały wyższe ogólne noty za cechy sensoryczne. Wyniki badań pozwalają na zalecanie nawet większego udziału nasion bobiku w mieszankach dla kurcząt brojlerów, bowiem poprawił on jakość mięśni piersiowych w kierunku prozdrowotnym.

Słowa kluczowe: kurczęta brojlery, mięśnie piersiowe, właściwości fizyko-chemiczne, walory sensoryczne, bobik