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Effectiveness of mixtures with the *fabaceae* seeds in broiler chicken feeding

Efektywność mieszanek z udziałem nasion roślin bobowatych stosowanych w żywieniu kurcząt brojlerów

Summary. The studies were conducted on four groups of the same number of broiler chickens ROSS 308 (each of 50 birds). The birds were fed Starter mixtures (12.8 MJ ME, 217 g total protein) for the first 21 days, and then Grower mixtures (13.1 MJ ME, 202 g total protein) for the next 3 weeks. Extracted soybean meal was used as the high protein feed in mixtures for chickens in the control group, while bean, pea and lupine seeds in the amount that corresponded to the same protein content (Starter – 15%, Grower – 33%) were applied in experimental mixtures instead of the soybean meal. The body weight gain, feed intake, dressing percentage, carcass musculature and fatness, the content of basic nutrients in breast muscles, pH_{15} and pH_{24} in the muscles as well as gustatory value of meat were analysed in the experiment. It was concluded that the introduction of *Fabaceae* seeds (regardless of species) into mixtures for broiler chickens significantly improved body weight gain ($P \leq 0.01$) and dressing percentage ($P \leq 0.05$) in birds with similar carcass musculature and fatness, and simultaneously sensory traits of meat were better ($P \leq 0.05$), compared to chickens that were fed mixtures, in which the extracted soybean meal was the only protein feed.

Key words: broiler chickens, bean, pea, lupine, performance and slaughter results

INTRODUCTION

The *Fabaceae* seeds such as: bean, pea and lupine are an underrated source of protein for farm animals. The extracted soybean meal in feed rations for monogastric animals (especially poultry) cannot be totally replaced by the seeds, without the worsening productive results. The seeds, however, could be used as a partial substitute that might

give a possibility to stop purchasing some amount of the extracted soybean meal. According to Poultry Nutrition Standards [2005], mixtures for broiler chickens should not contain more than 10% of lupine as well as 15% of bean or pea. Research from the last ten years showed that larger contents of the seeds could be used in mixtures for chickens, without any negative effects on their rearing results [Farrell *et al*. 1999, Osek *et al.* 2003, Arija *et al.* 2006, Emiola *et al.* 2007, Olkowski 2009, Gous 2011]. The *Fabaceae* seeds cannot be introduced into mixtures on the same level, because they differ not only in protein and fibre contents, but also in the content of antinutritional factors [Osek 1996, Sobotka 2004, Olkowski 2009].

The aim of the studies was to determine the effect of applying bean, pea and yellow lupine seeds in the amount that corresponded to the same total protein content in mixtures for broiler chickens.

MATERIAL AND METHODS

200 one-day-old broiler chickens ROSS 308, which were divided into 4 groups of the same number of birds (K, B, G, L), were used as an experimental material. There were 5 subgroups (each of 10 birds) in particular groups and the birds were reared for 42 days in metal cages in the standard environmental conditions. They were fed '*ad libitum*' and had a constant access to water. The chickens were fed the Starter mixture for the first 3 weeks, and then – the Grower mixture for the next 3 weeks. Birds in the control group (K) were fed mixtures that contained the extracted soybean meal as the protein feed, however, in mixtures for the experimental chickens some amount of the soybean protein was replaced by bean seeds (B), pea seeds (G) or lupine seeds (L).

Different levels of the *Fabaceae* seeds were introduced into mixtures (Tab. 1), but the total protein content was the same in the both types of mixtures (Starter – 15%, Grower – 33%). Before the recipes were composed, the *Fabaceae* seeds, which were the experimental factor, were chemically analysed (tab. 2) to determine the contents of the basic nutrients according to AOAC [1990]: Ca, K and Na contents by flame photometer, P content by the colorimetric method according to PN-76/R-64781. The results of the analyses related to the contents of protein, crude fibre and the basic macroelements were used to compose mixtures, following the requirements that are shown in Poultry Nutrition Standards [2005]. Moreover, the contents of the most important antinutritional factors were analysed: tannins – by BN-90/91160-42, phytates – by the Oberleas method [1971], trypsin inhibitors – by the Korol and Przegalińska's method [1994], alkaloids – by the Hermann-Nevdamm's method [1983].

The body weight of chickens (1, 21 and 42 days) and the feed intake in each rearing period were controlled during the experiment. Then, the body weight gain (BWG), feed conversion ratio (FCR) and European Index of Productivity (EIP) were calculated. EIP were calculated according following formula:

$$EIP = \frac{average\ body\ weight\ (kg)\ x\ mortality\ (\%)}{feed\ conversion\ ratio\ (kg)\ x\ days\ of\ rearing}\ x\ 100$$

Table 1. Composition components (g) and nutritive value of mixtures
Tabela 1. Skład surowcowy (g) i wartość pokarmowa mieszanek

Wyszczególnienie Item	Starter				Grower			
	K	B	G	L	K	B	G	L
Maize/Kukurydza	515.0	420.0	400.0	485.0	551.0	431.0	416.0	523.0
Bean/Bobik	–	135.0	–	–	–	195.0	–	–
Pea/Groch	–	–	155.0	–	–	–	225.0	–
Yellow lupine/Łubin żółty	–	–	–	85.0	–	–	–	122.0
Soybean meal/Śruta p. sojowa	400.0	350.0	360.0	340.0	360.0	270.0	275.0	255.0
Soybean oil/Olej sojowy	45.0	55.0	45.0	50.0	50.0	65.0	45.0	60.0
L-Lysine HCL/L-Lizyna	0.3	–	–	0.6	0.6	0.1	–	1.2
DL-Methionine/DL-Metionina	2.3	2.5	2.5	2.5	2.2	2.5	2.4	2.5
Limestone/Kreda pastewna	6.8	7.0	7.0	6.4	7.4	7.6	7.9	7.3
Dicalcium phosphate Fosforan 2-Ca	22.0	22.0	22.0	22.0	20.0	20.0	20.0	20.2
Salt/Sól pastewna	3.6	3.5	3.5	3.5	3.8	3.8	3.7	3.8
Premiks/Starter	5.0	5.0	5.0	5.0	–	–	–	–
Premiks/Grower	–	–	–	–	5.0	5.0	5.0	5.0
Nutritional value/Wartość pokarmowa (energy/energia, MJ·kg^{-1}, components/składniki, g·kg^{-1})								
Metabolizable energy Energia metaboliczna	12.86	12.77	12.84	12.74	13.15	13.12	13.11	13.10
Crude protein/Białko ogólne	217	217	219	217	203	202	202	202
Crude fibre/Włókno surowe	23.15	29.40	28.28	31.46	22.41	31.13	29.50	33.95
Lysine/Lizyna	12.82	13.11	13.58	12.99	12.08	11.98	12.35	11.99
Methionine/Metionina	5.79	5.77	5.86	5.81	5.51	5.42	5.40	5.45
Methionine + cystine Metionina + cystyna	9.66	9.53	9.72	9.92	9.16	8.81	8.92	9.35
Threonine/Treonina	8.97	8.98	9.17	8.81	8.35	8.09	8.25	7.83
Thryptophan/Tryptofan	2.84	2.77	2.84	2.71	2.62	2.43	2.47	2.33
Ca	9.57	9.60	9.60	9.45	9.25	9.21	9.28	9.23
Available phosphorus P przyswajalny	4.43	4.53	4.48	4.46	4.05	4.16	4.08	4.10
Na	1.67	1.60	1.60	1.61	1.74	1.70	1.66	1.70

At the age of 42 days of life, 5 hens and 5 cocks of the body weight, which represented the group and sex, were chosen from each group, and after that the birds were slaughtered by decapitation. After bleeding, plucking and roping, pH_{15} was measured in the left breast muscle (*m. pectoralis major*) and in the left thigh muscle (*m. iliotibialis*) by pH-meter with the stiletto type electrode. Then, the carcasses were chilled in refrigerator for 24 hours at temperature 0–4°C, and after the chilling the acidity of the muscles (pH_{24}) was measured and the simple slaughter analysis was carried out according to Zio-

łecki and Doruchowski [1989]. Samples of breast muscles were collected during the carcass cutting in order to analyse the content of basic nutrients according to AOAC [1990] and to estimate the sensory values of meat in Tilgner's 5-point scale [1957]. The estimation was conducted by 6 people who applied the methods presented by Baryłko-Pikielna [1975].

The results obtained in the experiment were statistically analysed by one-factor analysis of variance, and the significance of differences at level $\alpha = 0.05$ and $\alpha = 0.01$ between means in groups were tested using Duncan's multiple range test

RESULTS AND DISCUSSION

The analysis of the chemical composition of the *Fabaceae* seeds, which were used as an experimental factor (Tab. 2), showed lower total protein content in pea seeds, compared to the values presented in Poultry Nutrition Standards [2005], however, the content was larger by above 10 g in the experiment than in tests conducted by Sobotka [2004], and similar to the values showed in the Tables of Chemical Composition and Nutritive Values of Domestic Feeds [2010]. The bean seeds contained less total protein by about 2% than in works mentioned above, whereas slightly more total protein content was found in yellow lupine seeds. Moreover, the seeds contained less crude fat, but more nitrogen free extracts than the average content of the nutrient in seeds of the species proved by other researchers [Sobotka *et al*. 1995, Osek 1996 and Micek *et al*. 2012] and presented in Poultry Nutrition Standards [2005].

Table 2. Chemical composition of legume seeds
Tabela 2. Skład chemiczny nasion strączkowych

Item Wyszczególnienie	Bean Bobik	Pea Groch	Yellow lupine Łubin żółty
Basal nutrients/Składniki podstawowe ($g \cdot kg^{-1}$)			
Crude ash/Popiół surowy	3.60	2.81	4.03
Crude protein/Białko ogólne	24.51	21.29	39.13
Crude fibre/Włókno surowe	7.18	5.54	12.86
Crude fat/Tłuszcz surowy	1.11	0.88	4.64
N-free extractives/Związki bez-N wyciągowe	52.92	60.14	31.24
Macroelements/Makroelementy ($g \cdot kg^{-1}$)			
Ca	1.11	0.88	2.68
P	5.82	4.23	7.80
K	11.56	10.81	11.04
Na	0.10	0.08	0.11
Antynutritional factors/Substancje antyodżywcze			
Tannins/Taniny (%)	1.02	1.09	-
Phytates/Fityniany ($g \cdot kg^{-1}$)	10.83	9.77	7.82
Trypsin inhibitor/Inhibitory trypsyny ($mg \cdot g^{-1}$ białka)	-	20.34	-
Alkaloids/Alkaloidy (%)	-	-	0.10

Apart from the nutrients, there are also many antinutritional factors in the tested seeds, and phytates, tannins, trypsin inhibitors and alkaloids are the most important substances. The phytates content in 1 kg of the seeds ranged from 7.82 g in lupine to 10.83 g in bean seeds. According to Matyka [2007] there are less (by 1.37 g) of the chemicals in pea seeds, but more in bean and yellow lupine seeds (by 1.07 g and 6.88 g, respectively). Olkowski [2009] proved much more phytates (15.3–19.9 $g \cdot kg^{-1}$ dry matter) in four varieties of yellow lupine seeds. The tannin contents in pea and bean seeds were larger than presented by Sobotka *et al*. [1995], Osek [1996] and Emiola *et al*. [2007], whereas the content was lower than proved by Osek and Milczarek [2005]. The large tannin content in pea seeds might indicate that it was pea with inflorescences of colourful flowers (field pea). The results obtained by Maciejewicz-Ryś *et al.* [2000] showed that there are large differences in the tannin content also between bean varieties. The authors analysed 9 varieties of bean seeds and found that the varieties contained from 0.36 to 1.32 mg of catechin per gram. Thus, different results of the tannin content in bean seeds were mainly the result of the variety, and also the analytical methods that were applied in the analyses [Gatel *et al*. 1994].

Apart from tannins and phytates, the trypsin inhibitor content was tested in pea seeds, as well. The content amounted to 20.34 $mg \cdot g^{-1}$ of total protein. In studies by Matyka [2007] the trypsin inhibitor content in pea seeds was 11.5 $TIU \cdot mg^{-1}$ of total protein, whereas Sobotka [2004] found that it amounted to 3.84 $TUI \cdot mg^{-1}$ of dry matter.

Alkaloids are the most dangerous substances in lupine seeds. The alkaloid content in most varieties of Australian sweet lupine amounted to 100–500 $mg \cdot kg^{-1}$ and it was found that the content was not a threat for chicken health [Petterson 2000]. Considerably larger alkaloid content in the presented study was found (1 $g \cdot kg^{-1}$), however, it was similar to the results showed by other Polish researchers [Matyka 2007, Olkowski 2009, Kasprowicz-Potocka *et al.* 2013]. Olkowski [2009], who analysed 4 varieties of yellow lupine seeds, proved large differences in the alkaloid contents between the varieties (0.62 – 1.55 $g \cdot kg^{-1}$ of dry matter).

The *Fabaceae* seeds were used in the contents that introduced into mixtures the same amount of total protein, and positive effects of applying the seeds in chicken feeding on the body weight gain were found (Tab. 3). After the first rearing period no statistically significant differences in chicken body weight were proved in particular groups, however, after the second period, when the chickens were fed the Grower mixture, the differences were statistically significant. An average body weight of chickens in the experimental groups after 42 days of rearing was about 100 g larger than the body weight of chickens in the control group, and the differences were highly statistically proven. In other researchers' studies, either no effects or beneficial effects of different contents of leguminous seeds in mixtures on the production parameters were found. Osek *et al.* [2003] showed a significant effects ($P \leq 0.01$) of mixtures with bean seeds (Starter – 10%; Grower – 20%) on body weight gain in chickens, and no effects on the feed conversion ratio was also found. Suchy *et al*. [2010] replaced 1/3 or 2/3 of soybean protein with yellow lupine protein and did not find any differences in chicken body weight at the age of 42 days. No effects of mixtures with 40% of pea seeds on the body weight gain and feed conversion ratio in broiler chickens were also proved by Laudadio and Tufarelli

[2011]. On the other hand McNeill *et al*. [2004] after the introduction of 100 g of peas to the mixture obtained the same average body weight of experimental chickens as control, while the increase of peas in the mixture to 20% significantly reduced the body weight, but also reduced feed conversion per unit of gain. The results indicated that the *Fabaceae* seeds could partly substitute extracted soybean meal in diets for broiler chickens. In the presented studies no effects of different kinds of mixtures on feed conversion ratio were found, which was confirmed by earlier studies [Osek *et al*. 2003, Nalle *et al.* 2010, Laudadio and Tufarelli 2011] that tested the usefulness of on coarse-grained leguminous seeds in chicken broiler feeding.

Table 3. Rearing results and slaughter value of broiler chickens
Tabela 3. Wyniki odchowu i wartość rzeźna kurcząt brojlerów

Item Wyszczególnienie	Groups/Grupy				SEM
	K	B	G	L	
Body weight (g) in day/Masa ciała (g) w dniu					
21	828	824	802	824	14.81
42	2241^{B}	2339^{A}	2332^{A}	2343^{A}	22.54
Body weight gain /Przyrost masy ciała (g)					
1-21	786	781	760	783	13.21
22-42	1413	1515	1530	1519	19.82
1-42	2199^{B}	2296^{A}	2290^{A}	2302^{A}	20.55
FCR (kg)					
1-21	1.41^{b}	1.53^{a}	1.47^{ab}	1.47^{ab}	0.02
22-42	1.92^{a}	1.89^{ab}	1.83^{b}	1.83^{b}	0.03
1-42	1.72	1.76	1.71	1.70	0.06
EIP* (pkt)	296^{b}	316^{ab}	326^{a}	326^{a}	9.30
Dressing percentage Wydajność rzeźna (%)	78.1^{b}	78.8^{ab}	78.7^{ab}	79.8^{a}	0.45
Share in cold carcass/Udział w tuszce schłodzonej (%)					
Muscles total/Mięśni ogółem	43.79	43.63	43.83	44.24	0.75
including:/w tym:					
breast/piersiowych	23.37	23.02	23.53	23.72	0.71
thigh/udowych	11.88	12.03	11.77	12.00	0.37
drumstic/podudzi	8.51	8.58	8.53	8.53	0.25
Skin with subcutenous fat Skóry z tłuszczem podskórnym	11.31	11.72	12.82	13.26	0.60
Tłuszczu sadełkowego Abdominal fat	2.45	2.38	2.25	2.38	0.20

* European Index of Productivity/Europejski Indeks Produkcyjny
A, B, C – $P \leq 0.01$; a, b, c – $P \leq 0.05$

Dressing percentage, musculature and fatness are the basic parameters that characterize the slaughter value in broiler chickens. The largest dressing percentage (79.8%) in chickens fed mixtures containing the lupine meal was found and the parameter differed significantly ($P \leq 0.05$) only from the control group (78.1%). The kind of protein feeds in mixtures had no

statistically significant effect on both musculature (43.63% – 44.23%) and fatness of chicken carcasses. The lack of effects of the protein sources on the carcass traits in broiler chickens was also found by Masoero *et al.* [2005] and Laudadio and Tufarelli [2010]. The increase in the dressing percentage and in the total muscle content, but the slight decrease in fatness ($P > 0.05$) in broiler chickens fed mixtures with bean seeds of Akord variety (10% Starter; 20% Grower) were proved in Osek et al. studies [2003]. Suchỳ et al. [2010], however, stated lower dressing percentage and lower breast muscle content in carcasses of chickens that were fed mixtures with yellow lupine. Nalle *et al.* [2010], who applied the same amount of bean, white lupine or pea seeds in mixtures for broilers from 1 to 7 day of life and from 8 to 35 day of life (15% and 20%, respectively) did not find any significant effects of leguminous seeds on the dressing percentage in chickens.

The composition of mixtures could affect, not only the production parameters, but also the meat quality characteristics (nutritive value, pH, gustatory value). Mixtures used in chicken feeding significantly influenced all characteristics mentioned above (tab. 4). More mineral contents ($P \leq 0.05$) in breast muscles of birds fed mixtures with lupine or bean seeds than in the muscles of other chickens were found. The increase in crude ash content in breast muscles of chickens fed mixtures containing yellow lupine seeds was also proved by Suchỳ *et al*. [2010]. Less protein but more fat contents were stated in breast muscles of chickens fed mixtures with pea seeds. The fat content in muscles of the chickens was similar to that in the chickens from the control group, which could be caused by slightly larger metabolizable energy of the mixtures. Different results (significant decrease) concerning the fat content in meat of chickens fed mixtures with pea seeds were found by Laudadio and Tufarelli [2011].

Table 4. Basal nutrients content, acidity and sesnsory evaluation of breast muscles
Tabela 4. Zawartość składników podstawowych, odczyn i ocena sensoryczna mięśni piersiowych

Item Wyszczególnienie	Groups/Grupy				SEM
	K	B	G	L	
Basal nutrients/Składniki podstawowe (%)					
Dry matter/Sucha masa	27.28^{Aa}	26.53^{Ab}	26.20^{Bc}	26.51^{Ab}	0.14
Crude ash/Popiół surowy	1.21^{BCb}	1.27^{ABa}	1.19^{Cb}	1.30^{Aa}	0.01
Crude protein/Białko ogólne	24.36^{Aa}	23.97^{ABa}	23.25^{Bb}	23.73^{ABab}	0.20
Crude fat/Tłuszcz surowy	1.64^{a}	1.24^{b}	1.67^{a}	1.43^{ab}	0.09
Acidity/Odczyn					
pH_{15}	6.27^{b}	6.47^{ab}	6.51^{ab}	6.64^{a}	0.06
pH_{24}	5.92	5.92	5.95	5.91	0.06
Sensory scores (points)/Ocena sensoryczna (pkt)					
Flavour/Zapach	4.11^{b}	4.56^{ab}	4.44^{ab}	4.67^{a}	0.16
Juiciness/Soczystość	4.11	4.56	4.56	4.67	0.19
Tenderness/Kruchość	4.17^{b}	4.33^{ab}	4.56^{ab}	4.78^{a}	0.19
Palatability/Smakowitość	4.28	4.33	4.39	4.67	0.19
Mean of trials Średnia dla 4 cech	4.18^{b}	4.44^{ab}	4.46^{ab}	4.68^{a}	0.15

A, B, C – $P \leq 0.01$; a, b – $P \leq 0.05$

Acidity is another meat quality characteristic. Unfavourable influence of leguminous seeds on meat quality that was measured 15 minutes after the slaughter (pH_{15}) was proved. The pH_{15} acidity in breast muscles of the experimental chickens ranged from 6.47 (group B) to 6.64 (group L), whereas it amounted to 6.27 in the control group. According to classification Trojan and Niewiarowicz [1971] pH measured 15 minutes after the slaughter in normal meat amounted to 5.9–6.2, DFD meat has pH > 6.4 and PSE meat – pH < 5.7, so pH of breast muscles of experimental birds should be estimated as DFD (dark, firm, dry). It should be noticed, however, that there are many factors (apart from feeding) that have an effect on meat acidity. Genetic lines or conditions before the slaughter are some of the factors. Debut *et al.* [2003] measured pH in meat of fast- and slow-growing chickens, as well as in chickens that were under thermal stress and under stress caused by different transport conditions. They found that both breast and thigh muscles of fast-growing chickens were characterized by significantly larger pH_{15} (6.60) than those of slow-growing birds (6.31 and 6.56, respectively). The acidity of meat was not affected by the kind of stress that the birds were exposed to, and meat pH amounted to 6.44–6.59. The average value of pH_{15} for the whole population (N = 178) amounted to: 6.45 in breast muscles and 6.58 in thigh muscles. The results are similar to previous works of the paper authors and they showed that pH_{15} was frequently larger (regardless of the experimental factor) than that in normal meat (meat without faults). The next measurement of acidity breast muscle, made after 24 hours of chilling carcasses did not show significant differences between the mean values of pH in groups. The results obtained ranged from 5.91 to 5.95 and were characteristic for normal meat.

The organoleptic evaluation showed the best gustatory traits (4.68 points) in breast muscles of chickens fed mixtures with lupine seeds, whereas the worst traits in birds of the control group (4.18 points) were found. The differences in the traits between the groups were statistically significant ($P \leq 0.05$). An average estimation of muscles in other groups amounted to 4.45 points and the muscles did not differ from muscles of the control group and chickens of the L group in relation to sensory traits. The favourable effects of the *Fabaceae* seeds (bean) on the meat sensory traits in broiler chickens were also found in previous studies [Osek *et al.* 2003]. The authors stated that better estimation of all gustatory traits (average by 0.5 points) were proved in chickens fed mixtures with bean seeds than in birds of the control group.

CONCLUSION

Leguminous seeds (regardless of species) introduced into mixtures for broiler chickens in the amount of 15% (Starter) and 33% (Grower) of the total protein content significantly improved body weight gains, dressing percentage and meat sensory characteristics, while carcass musculature and fatness remained similar to those in chickens fed mixtures with extracted soybean meal as the only protein feed.

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Streszczenie. Badania przeprowadzono na 4 równolicznych (po 50 szt.) grupach jednodniowych kurcząt rzeźnych ROSS 308. Przez pierwsze 21 dni ptaki żywiono mieszankami starter (12,8 MJ EM, 217g b.og.), a przez kolejne 3 tygodnie grower (13,1 MJ EM, 202 g b.og.). W mieszankach dla kurcząt grupy kontrolnej paszą wysokobiałkową była poekstrakcyjna śruta sojowa, natomiast do mieszanek doświadczalnych w miejsce części śruty sojowej wprowadzono nasiona bobiku, grochu lub łubinu w udziałach wnoszących jednakową (starter – 15%, grower – 33%) ilość białka ogólnego. W doświadczeniu oceniono: przyrosty masy ciała ptaków, zużycie paszy, wydajność rzeźną, umięśnienie i otłuszczenie tuszki, zawartość składników podstawowych w mięśniu piersiowym, jego pH_{15} i pH_{24} oraz walory smakowe. Wykazano, że nasiona roślin bobowatych (niezależnie od gatunku) wprowadzone do mieszanek dla kurcząt brojlerów pozwalają na uzyskanie istotnie lepszych przyrostów masy ciała ($P \leq 0,01$) i wydajności rzeźnej ptaków ($P \leq 0,05$) przy podobnym umięśnieniu i otłuszczeniu tuszek oraz lepszych cechach sensorycznych mięsa ($P \leq 0,05$), w porównaniu z kurczętami żywionymi mieszankami, w których jedyną paszą białkową była śruta poekstrakcyjna sojowa.

Słowa kluczowe: kurczęta brojlery, bobik, groch, łubin, wyniki produkcyjne i poubojowe