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REARING RESULTS AND DIETETIC VALUE OF BROILER CHICKENS MEAT IN DEPENDENCE FROM GRAINS COMPOSITION IN MIXTURES OILED WITH SOYBEAN AND LINSEED OILS

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Abstract. The experiment was carried out on 200 ROSS 308 broiler chickens that were randomly assigned to 5 equal groups (K, D1, D2, D3, D4). The birds were fed the mixtures Starter (1–21 days of rearing) and Grower/Finisher (21–42 days) oiled with a mixture of soybean oil (3%) and linseed oil (3%). Two different grains represented the experimental factor, and were added to the mixtures in a 1:1 ratio, according to the following design: group K (control) – maize and wheat, group D1 – wheat and barley, group D2 – wheat and triticale, group D3 – maize and barley, group D4 – maize and triticale. It was shown that chickens fed the mixtures with triticale at age 42 days had significantly ($P \leq 0.01$) higher body weight than those that received mixtures with barley. In the whole period of rearing, a significantly ($P \leq 0.05$) lower feed conversion ratio was found in chickens fed diets containing wheat and barley, as compared with the control group. The used mixtures did not influence musculature and the proportion of skin with subcutaneous fat in carcasses; however, a significantly ($P \leq 0.05$) lower abdominal fat level was found in carcasses of chicken fed mixtures containing wheat and triticale and wheat and barley, as comparer with the broilers from other groups (K, D3 and D4). No effect of feeding on the content of most fatty acids in the lipids of leg muscles was found, while the breast muscles of the birds receiving the mixture with wheat and barley have shown a significant decrease in the proportion of linolenic acid and an increase in stearic acid. There were no significant effects of grain composition in mixtures in terms of muscle pH or sensory properties of the meat; they had, however, an impact on its color.

Key words: broiler chicken, cereal, feeding, meat quality, rearing performance

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INTRODUCTION

Broiler chickens grow very fast and require a large portion of feed, especially rich in metabolizable energy, of which the diet should contain about 13 MJ [Biesiada-Drzazga et al. 2011]. The basic source of the energy are cereals, which constitute about 60% of mixtures. The most popular in diets for broiler chickens are maize and wheat; however, their content in mixtures is reduced due to economic reasons [Korver et al. 2004, Zarghi, Golian 2009, Janocha et al. 2011]. One of the least expensive [Saki 2005] sources of energy for poultry include wheat and barley; however, the level of these cereals in mixtures should be limited due to the quantity of β-glucans in barley and arabinoxylans in wheat. Triticale is a grain that competes with the aforementioned species, in terms of lower soil requirements and high yielding potential with the nutritive value comparable to wheat. Triticale, however, is not popular component of mixtures for broiler chickens because it has the most changeable chemical composition (of all grains) and contains antinutritional factors [Pourreza et al. 2007]. In order to fill the energy demand of fast growing poultry, oil should be added to their feed mixtures (independently from the grain species and their proportions). Recent findings showed, that mixtures oiled with plant oils offer the best effects [Osek et al. 2001, Haug et al. 2007]; however, they differentiate the fatty acids profile, which effectively influence the fatty acids profile of animal products. Modification of this profile leading to obtaining more healthy food can be achieved by supplementation of the animal diet with omega-3 acids, of which linseed oil is an excellent source.

The aim of the study was to arrive at the best combination of grains in diets containing a mixture of soybean (3%) and linseed (3%) oils for broiler chickens.

MATERIAL AND METHODS

The experiment was carried out on 200 ROSS 308 broiler chickens, which were randomly assigned to 5 equal groups (K, D1, D2, D3, D4). In each feeding group there were 4 subgroups, 10 chickens each (5 cocks and 5 cockerels), which were reared until the age of 42 days. The birds were fed *ad libitum*, a loose feed mixtures and had constant access to water. The Starter diet were used in the first 3 weeks of rearing, followed by Grower/Finisher diet (without coccidiostat) fed over the next 3 weeks. Two different grains were the experimental factor, and they were added to the diets in 1:1 proportion, in the following design: Group K (control) – maize and wheat, Group D1 – wheat and barley, Group D2 – wheat and triticale, Group D3 – maize and barley, Group D4 – maize and triticale.

All the diets were formulated according to own recipes. The components used in the diets composition, i.e. crushed cereal meal, soybean meal, soybean oil and premix, were obtained from Feed Plant located in the Mazowieckie province, Poland. Linseed oil was extracted from flaxseed, which was purchased in the Seed Central and cold pressed on the individual farm. First the seeds were crushed, then heated to a temperature of approximately 72°C and pressed with a hydraulic press. All feed components were chemically analyzed for basic nutrients content, according to AOAC [1990], and the results were used to optimize the recipes. The content of metabolizable energy and basic nutrients in both types of diets (Starter and Grower/Finisher) were balanced according to the guidelines of the Poultry Nutrition Standards [2005]. The content of metabolizable energy, amino acids, minerals and vitamins were calculated according to Poultry Nutrition Standards [2005], and the level of crude protein and crude fiber were established by own analyses.

In this experiment broiler body weights (1, 21 and 42 days of age) and feed intake in each rearing period were recorded, and both live weight gain and feed conversion ratio (FCR) were calculated. At the age of 42 days, 5 females and 5 males with body weight typical of the group and sex were chosen from each group. After slaughter, pH_{15} was measured in the left breast muscle (*m. pectoralis major*) and in the left leg muscle (*m. iliotibialis*) using a pH-meter Seven Go™ SG2 Mettler Toledo with a glass probe electrode, with precision of ± 0.01. Afterwards, the carcasses were cooled at 0–4°C for 24 hours, and then pH_{15} was measured in the same muscles and simplified slaughter analysis was carried out according to Ziołecki and Doruchowski [1989]. Samples of breast and leg muscles were collected in order to test basic nutrient content by AOAC [1990] and fatty acid profile by gas chromatography using the Chrom 5 apparatus with a flame ionization detector (air – hydrogen). A glass column of 2.5 m length with Silar 5 CP was used with injector and detector temperature of 250°C and column temperature of 192°C. The carrier gas was nitrogen with a flow rate of 30 ml per minute. Taste properties of boiled meat samples were evaluated by a group of 6 people on a 5-point Tilgner's scale [1957], where 5 scores mean the best evaluation, 1 – the worst. Sensory properties were estimated according to the methodology described by Baryłko-Pikielna [1975]. Moreover, color brightness (CIE L* a* b*) of breast and thigh muscles were evaluated with using the Minolta Chroma Meter CR 300.

The results were statistically analyzed using one-way analysis of variance and significance of differences between means were tested in groups using Duncan multiple range test. Statistical analysis was performed using package STATISTICA ver. 6. [StatSoft® 2001].

RESULTS AND DISCUSSION

The chemical analysis of the used feed components are presented Table 1. There are differences in some nutrients if we compare the amount of basic nutrients in crushed cereal meal with the average content in the same cereals presented by Tables of Chemical Composition and Nutritive Values of Domestic Feeds [2010]. The highest difference was in the protein content. In 1 kg of ground triticale there was some 15 g less protein, but much more in ground maize. The low content of protein corresponds with reports stating that triticale has the most variable chemical composition (of all grains). In crushed cereal meal of wheat and barley, the protein level was approximately the same as presented in the aforementioned Tables, but in the both cereals we found over 1% more crude fiber and less (0.2%) crude fat. Fatty acids profiles of the oils used in the mixtures dif-

Table 1. Chemical composition of feed components

Tabela 1. Skład chemiczny komponentów paszowych

Basic nutrients content, % Zawartość składników podstawowych, %	Soybean meal Śruta poekstrakcyjna sojowa	Ground maize Śruta kukurydziana	Ground wheat Śruta pszenna	Ground triticale Śruta pszenżytnia	Ground barley Śruta jęczmienna
Dry matter – Sucha masa	90.98	89.94	87.79	87.55	88.22
Crude ash – Popiół surowy	6.19	2.08	1.77	1.63	2.49
Crude protein – Białko ogólne	44.34	10.65	12.14	9.94	11.05
Crude fibre – Włókno surowe	3.87	3.43	4.33	2.20	5.73
Crude fat – Tłuszcz surowy	1.59	4.41	1.47	1.50	2.39
N-free extractives – BAW	34.99	69.37	68.08	72.28	66.56

Share (% of sum) of fatty acids Udział (% sumy) kwasów tłuszczowych	Oil - Olej	
	soybean – sojowy	linseed – lniany
$C_{14:0}$ miristic – mirystynowy	0.06	0.02
$C_{16:0}$ palmitic – palmitynowy	11.23	4.62
$C_{16:1}$ palmitoleic – palmitooleinowy	0.04	–
$C_{18:0}$ stearic – stearynowy	2.35	3.06
$C_{18:1}$ oleic – oleinowy	23.41	17.84
$C_{18:2}$ linoleic – linolowy	57.23	16.56
$C_{18:3}$ linolenic – linolenowy	5.04	57.53
$C_{20:0}$ arachidic – arachidowy	0.10	–
$C_{20:1}$ eicosenic – eikozenowy	0.10	0.08
$C_{20:2}$ eicosadienic – eikozadienowy	0.03	0.02
$C_{22:0}$ erucic – erukowy	0.36	0.26
others – inne	0.05	0.01
Total – Razem	100.00	100.00
Saturated – Nasycone (SFA)	14.10	7.96
Unsaturated – Nienasycone (UFA)	85.85	92.03
Monounsaturated – Jednonienasycone (MUFA)	23.55	17.92
Polyunsaturated – Wielonienasycone (PUFA)	62.30	74.11
PUFA n–6/n–3	11.35:1	0.28:1

fered greatly. In linseed oil, there were almost by half less saturated fatty acids, and over 6% points more unsaturated fatty acids, as compared to soybean oil. Among saturated fatty acids in soybean oil palmitic acid ($C_{16:0}$) predominated, which with miristic acid ($C_{14:0}$) are classified as the so-called hypercholesterole-

Table 2. Composition of feed components ($g \cdot kg^{-1}$) and nutritive value of feed mixtures

Tabela 2. Skład komponentowy ($g \cdot kg^{-1}$) i wartość pokarmowa mieszanek paszowych

Specification Wyszczególnienie	Starter					Grower/Finisher				
	K	D 1	D 2	D 3	D 4	K	D 1	D 2	D 3	D 4
Maize – Kukurydza	270	–	–	265	260	300	–	–	300	285
Wheat – Pszenica	270	275	265	–	–	300	310	295	–	–
Triticale Pszenżyto	–	–	265	–	260	–	–	295	–	285
Barley – Jęczmień	–	275	–	265	–	–	310	–	300	–
Soybean meal Śruta poekstrakcyjna sojowa	361	351	371	371	381	300	280.7	311.5	300.10	330.90
Soybean oil Olej sojowy	30	30	30	30	30	30	30	30	30	30
Linseed oil Olej lniany	30	30	30	30	30	30	30	30	30	30
L-lysine – L-lizyna	0.50	0.50	0.50	0.50	0.50	1.50	1.50	1.00	1.40	0.80
DL-methione DL-metionina	2.40	2.40	2.40	2.40	2.40	2.40	2.50	2.30	2.40	2.20
Limestone Kreda pastewna	7.60	7.40	7.40	7.40	7.40	7.60	9.70	9.00	8.90	8.40
Dicalcium phosphate Fosforan 2–Ca	20.00	20.00	20.00	20.00	20.00	20.00	16.70	17.30	18.40	18.90
Salt – Sól	3.50	3.50	3.50	3.50	3.50	3.50	3.90	3.90	3.80	3.80
Premix – Premiks	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Total – Razem	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
1 kg of mixtures contain – 1 kg mieszanki zawiera:										
Metabolizable energy, MJ Energia metaboliczna, MJ	13.03	12.49	12.64	12.73	12.90	13.23	12.65	12.81	12.93	13.06
Crude protein, g Białko ogólne, g	221.60	219.41	218.32	222.01	217.87	201.39	196.35	198.03	198.16	200.36
Crude fibre, g Włókno surowe, g	27.76	34.51	28.14	32.91	26.70	27.00	34.54	27.47	32.70	25.97
Lys, g	12.20	12.31	12.88	12.58	12.91	11.64	11.56	11.92	11.69	11.96
Met, g	5.69	5.62	5.71	5.71	5.75	5.41	5.39	5.34	5.38	5.33
Met + Cys, g	9.52	9.54	9.75	9.53	9.65	8.95	9.00	9.11	8.86	8.99
Thr, g	8.39	8.35	8.01	8.59	8.12	7.47	7.31	7.06	7.53	7.31
Tryp, g	2.78	2.92	3.68	2.86	3.56	2.46	2.58	3.47	2.49	3.36
Ca, g	9.43	9.43	9.49	9.38	9.41	9.34	9.36	9.32	9.35	9.37
P available, g P przyswajalny, g	4.29	4.61	4.52	4.39	4.29	4.06	4.05	4.05	4.06	4.06
Na, g	1.59	1.56	1.57	1.59	1.60	1.69	1.70	1.70	1.69	1.70

mic fatty acids (OFA). There was 2.5 times more palmitic acid and 3 times more miristic acid than in linseed oil. In soybean oil, the content of palmitic acid was by as much as 2–5% points lower than those reported by Osek et al. [2001] and Matyka and Żelazowska [2006]. Moreover, in soybean oil there was 3.5 times more linoleic acid (adherent to omega-6 group), and 11 times less linolenic acid (omega-3), than in linseed oil, in which the latter acid predominated (57.53% of all acids) adherent to omega-3 group. The studies proved, that the share of the linolenic acid in linseed oil is variable. A lower amount, about 6% points of this acid in linseed oil was demonstrated by Matyka and Żelazowska [2006], Osek et al. [2006] Matyka [2007], and similar by Osek et al. [2007].

The composition of feed components and the calculated nutritive value of the feeds is shown in Table 2, whereas analyzed fatty acids profiles of the dietary lipids are presented in Table 3.

Table 3. Composition and share of fatty acids (% of sum) of feed mixtures

Tabela 3. Skład i udział (% sumy) kwasów tłuszczowych w mieszankach paszowych

Fatty acids – Kwasy tłuszczowe	Group – Grupa				
	K	D 1	D 2	D 3	D 4
Starter mixture – Mieszanka Starter					
$C_{18:2}$ linoleic – linolowy	43.86	40.09	43.01	40.39	42.91
$C_{18:3}$ linolenic – linolenowy	20.74	20.36	23.81	18.04	21.82
Saturated – Nasycone (SFA)	13.05	15.95	13.03	16.13	13.07
Unsaturated – Nienasycone (UFA)	86.82	83.93	86.88	83.85	86.79
Monounsaturated – Jednonienasycone (MUFA)	22.21	23.47	20.04	25.40	22.05
Polyunsaturated – Wielonienasycone (PUFA)	64.61	60.46	66.84	58.45	64.74
Neutral or hypocholesterolemic – Neutralne i hipocholesterolemiczne (DFA = $C_{18:0}$ + UFA)	89.40	86.53	89.48	86.63	89.32
Hypercholesterolemic – Hipercholesterolemiczne (OFA = $C_{14:0}$ + $C_{16:0}$)	10.29	13.17	10.26	13.14	10.36
PUFA n–6/n–3	2.11:1	1.97:1	1.80:1	2.24:1	1.96:1
Grower/Finisher mixture – Mieszanka Grower/Finiszer					
$C_{18:2}$ linoleic – linolowy	42.31	39.38	43.05	39.28	42.64
$C_{18:3}$ linolenic – linolenowy	22.04	18.66	23.50	17.07	22.40
Saturated – Nasycone (SFA)	12.77	16.71	12.53	16.54	12.65
Unsaturated – Nienasycone (UFA)	87.12	83.17	87.33	83.32	87.25
Monounsaturated – Jednonienasycone (MUFA)	22.75	25.02	20.76	26.26	22.19
Polyunsaturated – Wielonienasycone (PUFA)	64.37	58.15	66.57	57.06	65.06
Neutral or hypocholesterolemic – Neutralne i hipocholesterolemiczne (DFA = $C_{18:0}$ + UFA)	89.76	86.40	89.86	86.69	89.85
Hypercholesterolemic – Hipercholesterolemiczne (OFA = $C_{14:0}$ + $C_{16:0}$)	9.87	13.20	9.79	12.86	9.83
PUFA n–6/n–3	1.92:1	2.11:1	1.83:1	2.30:1	1.90:1

The fatty acids profiling of the lipids of the diets used in the experiment showed that in both Starter and Grower/Finisher diets the most of essential unsaturated fatty acids were found in feeds produced on the basis of wheat and triticale, slightly less by about 2% in the control and D4, and the least diet were introduced into wheat and barley, as well as maize and barley. In addition, these diets contained less palmitic acid and thus the share of hypercholesterolemic fatty acids (OFA) decreased by nearly one fourth. The calculated ratio of polyunsaturated fatty acids omega-6:omega-3 in all the mixtures was similar, but the most limited (1.8:1) was in the diets containing wheat and triticale.

Table 4. Rearing results of broiler chickens

Tabela 4. Wyniki odchowu kurcząt brojlerów

Specification – Wyszczególnienie	Group – Grupa					SEM
	K	D 1	D 2	D 3	D 4	
Body weight of bird, g – Masa ptaka, g:						
initial – początkowa	39.10	39.50	39.10	39.00	38.90	0.23
21 day – 21 dzień	943^{a}	847^{b}	888^{ab}	876^{ab}	895^{ab}	20.83
42 day – 42 dzień	2502^{B}	2487^{C}	2570^{A}	2440^{C}	2554^{A}	9.39
Conversion per 1 kg of body weight gain – Zużycie na 1 kg przyrostu masy ciała:						
feed, kg – paszy, kg						
1–21 days – 1–21 dni	1.31^{a}	1.30^{ab}	1.24^{b}	1.24^{b}	1.30^{ab}	0.02
22-42 days – 22–42 dni	1.98^{a}	1.94^{a}	1.81^{b}	1.87^{ab}	1.85^{ab}	0.09
1-42 days – 1–42 dni	1.78^{a}	1.75^{a}	1.64^{b}	1.68^{ab}	1.69^{ab}	0.05
metabolizable energy, MJ – energii metabolicznej, MJ						
1–21 days – 1–21 dni	17.15^{Aa}	16.23^{ABab}	15.61^{Bb}	15.73^{Bb}	16.79^{ABa}	0.30
22–42 days – 22–42 dni	26.32^{a}	24.51^{ab}	23.23^{b}	24.29^{ab}	24.21^{ab}	0.90
1–42 days – 1–42 dni	23.51^{a}	22.12^{ab}	21.04^{b}	21.79^{ab}	22.12^{ab}	0.53
crude fibre, g – białka ogólnego, g						
1–21 days – 1–21 dni	291.8^{a}	285.2^{ab}	269.7^{b}	273.3^{b}	283.9^{ab}	5.16
22–42 days – 22–42 dni	400.3^{a}	380.5^{ab}	359.3^{b}	371.9^{ab}	370.8^{ab}	13.86
1–42 days – 1–42 dni	366.4^{a}	354.8^{ab}	334.7^{b}	345.1^{ab}	348.8^{ab}	19.50

Means in rows with different letters differed significantly at a, b – $P \leq 0.05$; A, B, C – $P \leq 0.01$.

Wartości w wierszach oznaczone różnymi literami różnią się istotnie przy a, b – P ≤ 0,05; A, B, C – P ≤ 0,01.

On the initial day of experiment, the average body weights of chickens in all groups were similar (about 39 g), but after 3 weeks of rearing significant differences were noticed in this feature (Table 4). The highest (943 g) body weights were attained by birds from the control group, and the lowest (847 g) by those fed the diets prepared on the base of wheat and barley. The difference between these groups was statistically significant ($P \leq 0.05$). After the period of feeding Grower/Finisher diet, more ample differences in the body weights were observed. The chickens fed the mixtures with triticale (group D2 and D4) were highly significantly ($P \leq 0.01$) heaviest, whereas the lowest body weights were attained by birds receiving barley in diets (group D1 and D3). The rearing results of birds from these groups are a confirmation of previous studies by other authors [Koreleski et al. 2000, Janocha 2011, Stachurska 2013], who demonstrated that barley does not belong to the cereals which may be used in broiler chickens feeding without a decrease in the productive performance. A worse feed conversion ratio and, in consequence, a decrease in weight gains are caused by an excessive amount of non-starch polysaccharides, especially β-glucans, which was observed by other authors [Silva and Smithard 2002, Lazaro et al. 2003]. In the first and the second period and, in consequence, after the 6-week rearing, the lowest feed conversion ratio and nutrients components was observed in the chickens fed a diet containing wheat and triticale (group D2), with a significant ($P \leq 0.05$) difference from the control group. Santos et al. [2008] stated that triticale is worth being used as a cereal in diets for broilers, since it yields higher body weight of birds, in comparison with control chickens. According to Hermes and Johanson [2004] the improvement of body weight gain of chickens is only achieved when the share of triticale does not exceed 15% in the feed, and Zarghi and Golian [2009] prove that even 40% triticale in maize-soybean mixtures does not reduce the body weight of chickens.

Average body weight of chickens selected for slaughter did not differ statistically between groups, however the differences in cold carcasses were noticeable (Table 5).

Table 5. Results of postslaughter analysis of broiler chickens

Tabela 5. Wyniki analizy rzeźnej kurcząt

Specification – Wyszczególnienie	Group – Grupa					SEM
	K	D 1	D 2	D 3	D 4	
Weight, g – Masa, g:						
bird before slaughter – ptaka przed ubojem	2479	2500	2539	2502	2585	42.78
cold carcass – tuszki po schłodzeniu	1917^{Cb}	1943^{ABCb}	2006^{ABa}	1932^{BCb}	2022^{Aa}	21.63
Dressing percentage, % Wydajność rzeźna, %	77.3^{b}	77.7^{ab}	79.0^{a}	77.2^{b}	78.2^{ab}	0.35
Proportion in cold carcass,% – Udział w tuszce schłodzonej, %:						
total muscles – mięśni ogółem including – w tym:	45.75	46.89	46.12	46.56	47.02	0.50
– breast – piersiowych	25.75	26.95	26.13	26.79	26.81	0.39
– thigh – udowych	11.45	11.83	11.85	11.49	11.82	0.19
– drumstic – podudzi	8.52	8.35	8.14	8.26	8.14	0.13
skin with subcutaneous fat skóry z tłuszczem podskórnym	10.89	10.67	11.16	10.29	10.90	0.33
abdominal fat – tłuszczu sadełkowego	1.86^{Aa}	1.56^{Bbc}	1.51^{Bc}	1.75^{ABab}	1.78^{ABa}	0.68

Means in rows with different letters differed significantly at a, b – $P \leq 0.05$; A, B, C – $P \leq 0.01$.
Wartości w wierszach oznaczone różnymi literami różnią się istotnie przy a, b – $P \leq 0,05$; A, B, C – $P \leq 0,01$.

The carcasses of birds fed diets containing triticale were significantly ($P \leq 0.05$) heavier from those of birds of the remaining groups, and in comparison with the control group the difference was even highly significant ($P \leq 0.01$). The highest dressing percentage was attained by birds that received the mixtures with wheat and triticale, and the lowest by those fed control mixtures as well as diets containing maize and barley. The difference between those groups in size of this coefficient raised by almost 2% points, but was statistically significant ($P \leq 0.05$). Zarghi and Golian [2009], who carried out studies on chickens Ross 308, did not see a significant influence of a diet with different (0, 25, 50, 75, 100%) content of triticale – applied as a replacement of maize – on the dressing percentage. Also

Osek et al. [2010] noticed that despite the fact that higher body weight before slaughter of birds control group (mixtures with wheat and maize) in comparison with receiving diet with wheat and triticale, maize and triticale or with only triticale ($P \leq 0.05$), their dressing percentage were similar. The test mixtures in the experiment had no statistically significant effect on the musculature of chickens, despite that the share of total muscle carcasses was more (by 1.27% points) of birds fed the mixtures containing of wheat and triticale, in compare to the control chickens. This confirms the results obtained in earlier studies carried out by Osek et al. [2010]. In turn Korver et al. [2004] showed a slightly larger share of the breast muscles of the chickens receiving a mixtures with triticale compared to birds fed wheat. The least of abdominal fat was in the carcasses of chickens group D2 (wheat, triticale), and the most of the carcasses of birds controls ($P \leq 0.01$). In addition, it was found that the higher the level of $P \leq 0.05$ share of abdominal fat in the carcass were characterized by chickens fed mixtures, which accounted for half of the raw cereal, maize (groups: K, D3 and D4). This fact combined with a slightly higher energy value of feed, that these birds received.

Used in the rearing of chickens mixtures containing different combinations of cereals did not affect the content of basic (exception – the level of protein in the breast muscles) in both breast muscles and legs (Table 6).

Table 6. Content (%) of chemical basic nutrients in meat

Tabela 6. Zawartość (%) podstawowych składników chemicznych w mięsie

Specification Wyszczególnienie		Dry matter Sucha masa	Crude ash Popiół surowy	Crude protein Białko ogólne	Crude fat Tłuszcz surowy
		Breast muscles – Mięśnie piersiowe			
Group Grupa	K	25.66	1.34	23.56^{Aa}	1.12
	D 1	25.23	1.18	23.23^{ABabc}	1.08
	D 2	25.18	1.17	22.90^{Bc}	1.01
	D 3	25.38	1.08	23.35^{ABab}	0.93
	D 4	25.48	1.15	23.08^{ABbc}	1.10
SEM		0.15	0.08	0.13	0.07
		Leg muscles – Mięśnie nóg			
Group Grupa	K	25.12	1.09	19.30	4.68
	D 1	25.34	1.08	19.36	4.71
	D 2	24.50	1.09	19.10	4.17
	D 3	24.98	1.07	19.62	4.14
	D 4	24.26	1.00	19.04	3.90
SEM		2.60	0.12	0.28	0.36

Means in rows with different letters differed significantly at a, b – $P \leq 0.05$; A, B – $P \leq 0.01$.
Wartości w wierszach oznaczone różnymi literami różnią się istotnie przy a, b – $P \leq 0,05$; A, B – $P \leq 0,01$.

The most of crude protein found in muscle control chickens and the least in birds fed with mixtures prepared on the basis of wheat and triticale. The difference between these groups amounting to 0.66% points were statistically significant ($P \leq 0.01$). Less ($P \leq 0.05$) protein also contained the breast muscles of chickens from groups D1 and D4 compared to muscle control birds. No major differences in the chemical composition of meat of broiler chickens ROSS 308 has been shown in studies Osek et al. [2010], which concerned the possibility of partial or total replacement in mixtures of wheat and maize – triticale.

The studies were analyzed in addition to the basic nutrients of the fatty acid profile in the lipid fraction of both muscles (Table 7).

Table 7. Share (% of sum) of fatty acids in lipid fraction of muscles

Tabela 7. Udział (% sumy) kwasów tłuszczowych we frakcji lipidowej mięśni

Fatty acids Kwasy tłuszczowe	Breast muscles – Mięśnie piersiowe					SEM	Leg muscles – Mięśnie nóg					SEM
	K	D 1	D 2	D 3	D 4		K	D 1	D 2	D 3	D 4	
$C_{14:0}$	0.23^{a}	0.22^{ab}	0.19^{b}	0.20^{ab}	0.23^{ab}	0.01	0.23	0.23	0.19	0.20	0.23	0.21
$C_{14:1}$	0.04^{a}	0.03^{b}	0.02^{b}	0.02^{b}	0.03^{ab}	0.03	0.07	0.05	0.04	0.04	0.06	0.01
$C_{16:0}$	20.12	20.12	19.45	19.79	19.61	0.45	18.07	17.96	17.24	17.25	17.95	0.57
$C_{16:1}$	2.46	2.19	1.87	1.63	2.05	1.06	2.55	2.63	2.45	2.20	2.54	0.37
$C_{18:0}$	5.90^{Cc}	6.60^{Babc}	6.33^{BCbc}	7.30^{Aa}	6.87^{ABab}	0.18	4.70	4.77	4.87	4.93	4.59	0.21
$C_{18:1}$	32.13^{a}	30.62^{ab}	30.84^{ab}	31.29^{ab}	30.49^{b}	0.46	31.25	29.82	30.07	29.53	30.08	0.84
$C_{18:2}$	26.61^{b}	27.14^{ab}	28.01^{a}	27.38^{ab}	28.05^{a}	0.85	28.86	29.78	29.57	31.48	29.80	0.95
$C_{18:3}$	11.28^{a}	11.72^{a}	11.89^{a}	10.90^{b}	11.33^{a}	0.38	13.46	13.84	14.62	13.31	13.64	0.54
$C_{20:1}$	0.10	0.16	0.11	0.13	0.13	0.02	0.11	0.08	0.11	0.09	0.09	1.05
$C_{20:2}$	0.09	0.12	0.10	0.11	0.12	0.01	0.06	0.06	0.07	0.07	0.07	0.005
$C_{20:3}$	0.08^{AB}	0.09^{AB}	0.11^{A}	0.12^{A}	0.06^{B}	0.01	0.05^{ab}	0.07^{a}	0.05^{ab}	0.06^{ab}	0.04^{b}	0.007
$C_{20:4}$	0.61	0.72	0.72	0.87	0.70	0.09	0.27^{b}	0.34^{ab}	0.36^{ab}	0.40^{a}	0.34^{ab}	0.04
$C_{22:0}$	0.09^{Bc}	0.06^{b}	0.14^{a}	0.08^{b}	0.13^{a}	0.17	0.07^{B}	0.12^{B}	0.08^{B}	0.15^{B}	0.33^{A}	0.02
Others Inne	0.26	0.21	0.22	0.18	0.20	0.01	0.25	0.25	0.28	0.29	0.24	0.02
SFA	26.34^{B}	27.00^{AB}	26.11^{B}	27.37^{A}	26.84^{AB}	0.34	23.07	23.08	22.38	22.53	23.10	0.60
UFA	73.40^{a}	72.90^{ab}	73.67^{a}	72.45^{b}	72.96^{ab}	0.36	76.68	76.67	77.34	77.18	76.66	0.60
MUFA	34.73^{a}	33.00^{ab}	32.84^{b}	33.07^{ab}	32.70^{b}	0.53	33.98	32.58	32.67	31.86	32.77	1.03
PUFA	38.67	39.79	40.83	39.38	40.26	0.65	42.70	44.09	44.67	45.32	43.89	1.46
DFA	79.30	79.50	80.00	79.75	79.83	0.65	81.38	81.44	82.21	82.11	81.25	0.60
OFA	20.35	20.34	19.64	19.99	19.84	0.59	18.30	18.19	17.43	17.45	18.18	0.58
n–6 / n–3	2.41:1	2.37:1	2.41:1	2.59:1	2.53:1	0.04	2.16:1^{Bbc}	2.17:1^{Bbc}	2.04:1^{Bc}	2.39:1^{Aa}	2.20:1^{Bb}	0.04

Means in rows with different letters differed significantly at a, b – $P \leq 0.05$; A, B, C – $P \leq 0.01$.
Wartości w wierszach oznaczone różnymi literami różnią się istotnie przy a, b – $P \leq 0,05$; A, B, C – $P \leq 0,01$.

It was shown that triticale whether it is used in conjunction with wheat or maize resulted in an increase of polyunsaturated fatty acids (PUFA) in the breast muscle lipid. In addition, decreased ($P \leq 0.05$) in which the level of saturated fatty acids (SFA), in particular miristic acid ($P \leq 0.05$) and palmitic ($P > 0.05$), included in hypercholesterolemic fatty acids. Of particular note is the effect of triticale to increase share in the breast muscles of essential fatty acids [linoleic acid ($C_{18:2}$) and linolenic acid ($C_{18:3}$)], with anti-atherosclerotic action and anti-cholesterol. The fatty acid profile of the lipid fraction of leg muscles, no significant intergroup differences that would have been confirmed as statistically significant. However, as in the case of breast muscle was observed that a leg muscle lipid the chickens of group D2 had the least saturated fatty acids (especially hypercholesterolemic), and more polyunsaturated, which should be considered a positive. It is worth noting that the applied feeding allowed to obtain in both muscle near perfect (recommended by the WHO, 2003) the ratio of polyunsaturated fatty acids from the omega-6: omega-3, which in breast muscles averaged about 2.5:1, and leg muscles was even narrower approximately 2.2:1. This is obviously a result of used linseed oil (3%) and soybean (3%), because the use of soybean oil alone does not allow to obtain this result. This is evidenced by research conducted by Osek et al. [2010], also on hybrids chickens ROSS 308 and fed mixtures, which were also mixtures of different cereals (wheat and maize, wheat and triticale, maize and triticale as well as self-triticale). They have been shown that, irrespective of the value of the composition cereal was very wide and ranged from 27.18 in the group with the triticale to 28.73 where in mixture was maize and triticale.

There were no significant effects of the applied feeding on breast muscle pH measured after 45 minutes of slaughter and after 24 hours of cooling, with the exception of the group D4. Significant differences were found in the initial pH of thigh muscles. The highest pH_1 (6.33) were thigh muscles of chickens fed with wheat and triticale (D2), slightly lower (6.28) in the group of birds D3 and D4, and the lowest (6.15) in muscle control chickens. The difference in acidity of thigh muscles between those groups has been confirmed as a highly statistically significant (Table 8).

Meat of all meat chickens were normal, free of defects, since the amount of pH_1 was below 6.4, which qualifies as defective meat (DFD – dark, firm, dry). Higher pH muscle (especially pH_1 – breast muscles 6.33–6.53; thigh muscles 6.27–6.41) of chickens fed with mixtures which included the same or similar compositions of cereals reported in studies Osek et al. [2010]. In turn Debut et al. [2003] although analyzed the impact of the line and the pre-slaughter chickens for meat pH, but it fed mixtures prepared from maize and wheat, they found that after 15 minutes of slaughter mean pH in breast muscles ranged from 6.31–6.60, and was more aligned in thigh and ranged 6.56–6.60, regardless of the tested factors.

Feeding chickens with mixtures containing different cereals also had an impact on the lightness (L*) color of the breast muscles. The brightest muscles chickens were fed with mixtures of wheat and triticale, and the darkest derived from chickens fed the control and mixtures of maize and barley ($P \leq 0.05$). However, applied mixtures of cereals did not affect the brightness of the color of thigh muscle, but demonstrated much greater ($P \leq 0.01$) in the direction of the colour saturation of yellow, muscle of chickens fed with mixtures of wheat and barley, and maize and barley compared to the muscles of the birds receiving mixtures containing wheat and triticale. Sensory characteristics of both breast muscles as well as the thigh such as: flavour, juiciness, tenderness, palatability, did not depend significantly on the composition of cereals placed on the mixtures.

Table 8. Physical and sensory properties of broiler chicken muscles

Tabela 8. Cechy fizyczne i organoleptyczne mięśni kurcząt brojlerów

Specification –Wyszczególnienie	Group – Grupa					SEM
	K	D 1	D 2	D 3	D 4	
Breast muscles – Mięśnie piersiowe						
Physical properties – Cechy fizyczne						
pH_1	6.17	6.23	6.18	6.18	6.24	0.04
pH_{24}	6.03[a]	5.96[ab]	5.97[ab]	5.96[ab]	5.91[b]	0.02
Colour – Barwa CIE L*	47.83[b]	48.88[ab]	50.29[a]	48.04[b]	48.04[ab]	0.62
a*	3.42	3.83	3.77	3.77	3.55	0.23
b*	1.57	1.59	1.57	1.53	1.61	0.21
Sensory properties, score – Cechy organoleptyczne, pkt						
Flavour –Zapach	4.5	4.8	4.5	4.8	4.6	0.15
Juiciness – Soczystość	4.6	4.7	4.4	4.5	4.4	0.23
Tenderness – Kruchość	4.7	4.8	4.3	4.6	4.7	0.16
Palatability – Smakowitość	4.6	4.8	4.5	3.7	4.5	0.23
Thigh muscles – Mięśnie udowe						
Physical properties – Cechy fizyczne						
pH_1	6.15[Bc]	6.22[ABbc]	6.33[Aa]	6.28[Aab]	6.28[Aab]	0.03
pH_{24}	6.38	6.36	6.42	6.39	6.37	0.02
Colour – Barwa CIE L*	47.78	48.68	48.20	47.36	47.30	0.47
a*	12.56	12.99	12.56	12.90	12.60	0.31
b*	2.95[ABa]	3.09[Aa]	2.23[Bb]	3.12[Aa]	2.53[ABab]	0.20
Sensory properties, score – Cechy organoleptyczne, pkt						
Flavour –Zapach	4.7	4.8	4.6	4.7	4.8	0.14
Juiciness – Soczystość	4.7	5.0	4.5	4.8	4.7	0.16
Tenderness – Kruchość	4.7	4.8	4.6	4.8	5.0	0.15
Palatability – Smakowitość	4.7	5.0	4.7	4.8	4.8	0.14

Means in rows with different letters differed significantly at a, b – $P \leq 0.05$; A, B – $P \leq 0.01$.

Wartości w wierszach oznaczone różnymi literami różnią się istotnie przy a, b – $P \leq 0,05$; A, B – $P \leq 0,01$.

CONCLUSION

The results obtained in this experiment showed that mixtures with wheat and triticale, oiled mixture with oils: soybean (3%) and linseed (3%) could be recommended in broiler chickens feeding, which allow on obtainment the most profitable rearing results of birds as well as the best dietetic values of meat.

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WSKAŹNIKI ODCHOWU I WARTOŚĆ DIETETYCZNA MIĘSA KURCZĄT BROJLERÓW W ZALEŻNOŚCI OD KOMPOZYCJI ZBÓŻ W MIESZANKACH NATŁUSZCZONYCH OLEJEM SOJOWYM I LNIANYM

Streszczenie. Doświadczenie przeprowadzono na 200 kurczętach brojlerach ROSS 308, które rozdzielono losowo do 5. równolicznych grup (K, D1, D2, D3, D4). Kurczęta żywiono mieszankami Starter (1–21 dni) i Grower/Finiszer (22–42 dni) natłuszczonymi mieszaniną oleju sojowego (3%) i lnianego (3%). Czynnikiem różnicującym grupy były 2 zboża wprowadzone do mieszanek w udziale 1:1 wg układu: grupa K (kontrolna) – kukurydza i pszenica; grupa D1 – pszenica i jęczmień, grupa D2 – pszenica i pszenżyto, grupa D3 – kukurydza i jęczmień, grupa D4 – kukurydza i pszenżyto. Wykazano, że kurczęta żywione mieszankami z pszenżytem w wieku 42 dni uzyskały istotnie ($P \leq 0{,}01$) wyższe masy ciała niż otrzymujące mieszanki z jęczmieniem. Istotnie ($P \leq 0{,}05$) niższym zużyciem paszy w całym okresie odchowu w odniesieniu do grupy kontrolnej charakteryzowały się kurczęta żywione dietami zawierającymi pszenicę i pszenżyto. Stosowane mieszanki nie wpłynęły na umięśnienie i udział skóry z tłuszczem podskórnym w tuszkach, natomiast wykazano istotnie ($P \leq 0{,}05$) mniej tłuszczu sadełkowego w tuszkach kurcząt żywionych mieszankami z udziałem pszenicy i pszenżyta oraz pszenicy i jęczmienia w porównaniu do ptaków z pozostałych grup (K, D3 i D4). Nie stwierdzono wpływu żywienia na udział większości kwasów tłuszczowych w lipidach mięśni nóg, natomiast w mięśniach piersiowych ptaków otrzymujących mieszanki z pszenicą i jęczmieniem wykazano istotne obniżenie ilości kwasu linolenowego oraz zwiększenie stearynowego. Nie odnotowano istotnego oddziaływania kompozycji zbóż w mieszankach na odczyn mięśni, jak też na wyróżniki smakowe, natomiast miały one wpływ na jego barwę.

Słowa kluczowe: jakość mięsa, kurczęta brojlery, wyniki odchowu, zboża, żywienie

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