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EFFECT OF TRITICALE AS A PARTIAL OR COMPLETE WHEAT AND MAIZE SUBSTITUTE IN BROILER CHICKEN DIETS ON GROWTH PERFORMANCE, SLAUGHTER VALUE AND MEAT QUALITY

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Abstract

The effect of triticale as a replacement for wheat or maize in feed mixtures for broiler chickens or as the only grain on productivity, slaughter results, and physico-chemical and organoleptic characteristics of meat was studied. The use of triticale in the diets for broilers decreased (P≤0.05; P≤0.01) their body weight (by 4% when used as a wheat substitute and by 8% when used instead of maize or as the only grain) and reduced feed conversion per kg of live weight gain (by 8 and 14%, respectively). The type of grain had no significant effect (P>0.05) on dressing percentage and carcass muscularity. The meat of chickens fed diets containing triticale or triticale and maize was characterized by similar taste properties to the meat of control chickens, but combined feeding of triticale and wheat had an adverse effect on the taste of meat. Feeding triticale alone or in combination with wheat significantly (P≤0.05) improved the profile of fatty acids in breast muscle lipids in a way that provides health benefits.

Key words: triticale, rearing performance, slaughter value, meat quality, broiler chicken

Maize and wheat are mainly used in production of feed mixtures for broilers, but their content in diets should be reduced for economic reasons (Korver et al., 2004; Józefiak et al., 2007; Zarghi and Golian, 2009). Triticale is a grain that competes with other species in terms of lower soil requirements and high yielding potential and nutritive value, which are comparable to wheat (Nutritional Recommendations, 2005). Triticale, however, was not a 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). Studies on the possibility of using triticale in broiler chicken diets were carried out in the 1980s and 1990s (Koreleski and Ryś, 1987; Proudfoot and Hulan, 1988; Klocek and Adamczyk, 1994; Śliwiński et al., 1998), but they generally concentrated on the estimation of rearing performance and showed decreased live weight gain and increased feed conversion

ratio. Recent findings (Korver et al., 2004; Matyka and Rubaj, 2004; Józefiak et al., 2007; Santos et al., 2008) were not so clear and in most cases showed no effect of grain on slaughter value and quality of poultry meat.

The aim of the study was to determine the effect of triticale as a partial or complete wheat and maize substitute in feed mixtures on rearing performance and carcass quality in broiler chickens.

Material and methods

The experiment was carried out on 160 Ross 308 day-old broiler chickens that weighed 45 g on average. The birds were randomly assigned to 4 equal groups (M/W, W/T, M/T, T) with 5 subgroups (8 birds each). The chickens were kept in metal cages (0.53 m^2) and reared up to 42 days of age in standard environmental conditions. The birds were fed *ad libitum* and had constant access to water. They were fed a starter diet from day 1 to 3 weeks of age, and a grower diet over the next 3 weeks. Triticale cultivar Gniewko was the experimental factor, and it was introduced into the mixtures as a replacement for wheat, maize or both grains according to the following design: group M/W – maize and wheat, group W/T – wheat and triticale, group M/T – maize and triticale, group T – triticale.

Table 1. Chemical composition (%) of raw materials

Item	Triticale	Wheat	Maize	Soybean meal
Dry matter	88.74	88.08	90.00	90.89
Crude ash	2.01	1.96	1.38	6.51
Crude protein	13.32	12.47	8.78	46.00
Crude fibre	3.24	3.44	1.83	4.07
Crude fat	1.01	1.99	3.38	1.99
N-free extractives	69.16	68.22	74.63	32.32

All the mixtures were formulated by the authors. The nutrient content of the components was previously analysed (Table 1), while the content of metabolizable energy was based on standards (Nutritional Recommendations, 2005). The content of nutrients and metabolizable energy in both mixtures (Table 2) was balanced following the guidelines of the Nutritional Recommendations (2005). 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. All cullings were also recorded. The data were used to calculate the European Production Index (EPI). 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 and slaughtered by decapitation. After bleeding and plucking, pH_{15} was measured in left breast muscle (*m. pectoralis major*) and in left leg muscle (*m. iliotibialis*) using a pH-meter with glass probe electrode. Afterwards, carcasses were chilled at 0–4°C for 24 hours, and then pH_{24} 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 a 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 on a 5-point scale by a group of 6 people, according to the methodology described by Baryłko-Pikielna (1976).

Table 2. Composition (%) and nutritive value of feed mixtures

Item	Starter				Grower			
	M/W	W/T	M/T	T	M/W	W/T	M/T	T
Maize	27.00	-	27.00	-	30.00	-	30.50	-
Wheat	27.00	28.00	-	-	30.00	32.00	-	-
Triticale	-	28.00	27.00	57.00	-	32.00	30.50	65.00
Soybean meal	36.20	34.20	36.20	33.20	30.10	26.10	29.12	25.10
Soybean oil	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Premix L-lysine 99	0.05	0.05	0.05	0.05	0.10	0.15	0.13	0.15
Premix DL-methionine 99	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Limestone	0.66	0.66	0.66	0.66	0.70	0.70	0.70	0.70
Dicalcium phosphate	2.00	2.00	2.00	2.00	1.98	1.93	1.93	1.93
Salt	0.35	0.35	0.35	0.35	0.38	0.38	0.38	0.38
Premix Starter*	0.50	0.50	0.50	0.50	-	-	-	-
Premix Grower*	-	-	-	-	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nutritive value per kg of mixture:								
Metabolizable energy (MJ)	13.11	12.80	13.04	12.75	13.30	13.01	13.26	12.95
Crude protein (g)	224	229	226	228	202	202	202	202
Crude fibre (g)	28.96	32.62	28.42	31.98	28.06	32.00	27.32	31.28
Lysine (g)	12.23	12.17	12.44	12.16	11.18	11.17	11.47	11.19
Methionine (g)	5.69	5.58	5.67	5.50	5.42	5.21	5.34	5.13
Methionine + Cystine (g)	9.53	9.49	9.48	9.34	8.97	8.76	8.81	8.60
Threonine (g)	8.41	7.55	7.81	6.76	7.49	6.25	6.67	5.37
Thryptophan (g)	2.78	3.58	3.49	4.28	2.47	3.28	3.21	4.09
Ca (g)	9.56	9.52	9.48	9.41	9.42	9.22	9.19	9.10
P available (g)	4.30	4.49	4.27	4.45	4.18	4.31	4.06	4.27
Na (g)	1.59	1.56	1.59	1.55	1.69	1.65	1.69	1.65

* 1 kg of mixtures from Starter/Grower premix contained: vitamins A – 13500/13500 i.u., D_3 – 10000/10000 i.u., E – 80/40 mg, K – 4/3 mg, B_1 – 3/2 mg, B_2 – 8.75/7.75 mg, B_6 – 5/4 mg, B_{12} – 0.024/0.024 mg, PP – 70/70 mg, B5 – 25/20 mg, B_9 – 2.00/1.75 mg, H – 0.20/0.20 mg, B_t – 500/500 mg; microelements Fe – 80/80 mg, Mn – 100/100 mg, Zn – 80/80 mg, Cu – 9/8 mg, I – 1.25/1.25 mg, Se – 0.275/0.275 mg, Co – 0.30/0.25 mg, Ca – 1.311/1.248g, coccidiostat; antioxidant.

The results were statistically analysed using one-factor analysis of variance and significance of differences between means was tested in groups using Duncan's multiple range test (Statsoft, 2001).

Results

Mixtures that were used in broiler feeding caused differences in body weight. After 3 weeks, broiler chickens fed diets containing only triticale as a grain component had the highest body weight (Table 3), and birds fed wheat and triticale diets had the lowest body weight with a non-significant difference (P>0.05). In each group, broiler body weights became different after the application of grower diet. The introduction of triticale alone (group T) or with maize (group M/T) into mixtures decreased body weight of the birds by almost 200 g compared to birds receiving maize and wheat diets (P≤0.01) and by 100 g compared to broilers from group W/T (P≤0.05). The analysis of average feed intake (g/bird/day) during the whole rearing period showed that chickens from groups W/T and T had higher feed intake by 4% compared to chickens from the other groups. The replacement of triticale with maize or wheat, or the use of triticale as the only grain substitute had a negative effect on feed efficiency. FCR was similar in groups W/T and M/T, and over 8% higher than in the control group (P≤0.05). In chickens from group T, FCR was higher by almost 14% compared to the control group (P≤0.01) and by about 5% compared to the other groups. Chickens from the control group were characterized by significantly better (P≤0.05) EPI than chickens fed diets containing maize and triticale or only triticale. This parameter was higher by 64 and 69 points, respectively.

Table 3. Results of rearing and postslaughter analysis of broiler chickens

Item	Groups				SEM
	M/W	W/T	M/T	T	
Body weight (g):					
21 day	730	708	727	739	19.57
42 day	2558 Aa	2465 ABb	2362 Bc	2363 Bc	24.93
Feed intake (g/head/day):					
1–21 days	49.11 b	50.60 ab	51.10 ab	53.01 a	1.01
21–42 days	140.02 ab	145.70 a	137.78 b	145.09 a	6.56
1–42 days	94.80 b	98.16 a	94.40 b	99.14 a	3.58
Feed conversion ratio (kg):					
1–21 days	1.50 Cc	1.61 ABb	1.68 Bb	1.72 Aa	0.01
21–42 days	1.61 Cc	1.75 ABb	1.71 Bb	1.83 Aa	0.02
1–42 days	1.58 Bb	1.71 ABa	1.70 ABa	1.80 Aa	0.03
EPI* (points)	373 a	331 ab	309 b	304 b	12.72
Body weight before slaughter (g)	2508 A	2430 B	2335 C	2352 C	15.74
Weight of cold carcass (g)	1956 Aa	1924 ABa	1833 Cb	1857 BCb	17.31
Dressing percentage	78.01	79.15	78.52	78.92	0.41
Proportion in cold carcass (%):					
Muscles total including:	45.76	45.15	46.43	45.55	0.61
breast	24.96 ab	25.15 ab	26.29 a	24.73 b	0.47
thigh	12.00	12.06	11.84	12.21	0.36
drumstick	8.81 a	7.95 b	8.29 ab	8.61 a	0.20
Skin with subcutaneous fat	10.94 ABbc	12.74 Aa	10.54 Bc	11.78 Aab	0.28
Abdominal fat	1.46	1.55	1.49	1.77	0.16

* – European Production Index,
A, B, C – values in rows with different letters differ significantly, P≤0.01.
a, b, c – values in rows with different letters differ significantly, P≤0.05.

The analysis of slaughter value also showed some differences. Despite higher body weight in control birds compared to the other groups (P≤0.05), their dressing percentage was similar, which shows that the introduction of triticale into mixtures had no effect on this parameter. There was no significant influence of triticale on total muscle content in chilled carcasses, although some differences were found between the groups in the content of each muscle. Broiler chickens receiving maize and triticale diets had the highest content of breast muscle and the lowest body fat content. On the other hand, chickens fed diets with only triticale were characterized by the smallest breast muscles and the largest thigh muscles. Statistically significant differences were found between M/T and T groups and between M/W, T and W/T groups in breast muscle content. The highest content of skin with subcutaneous fat was observed in chickens fed wheat and triticale diets.

Table 4. Physico-chemical characteristics of muscles

Item	Groups				SEM
	M/W	W/T	M/T	T	
Breast muscles					
dry matter (%)	25.80	25.88	26.36	25.73	0.37
crude ash (%)	1.18 Aa	1.16 Bc	1.18 ABab	1.17 ABbc	0.003
crude protein (%)	23.18	22.95	23.75	23.10	0.34
crude fat (%)	1.23	1.27	1.66	1.25	0.14
pH_1	6.34	6.40	6.53	6.33	0.36
pH_{24}	6.01	6.00	5.92	5.88	0.32
Thigh muscles					
dry matter (%)	26.50 a	25.19 b	24.92 b	25.09 b	0.32
crude ash (%)	1.07	1.05	1.09	1.08	0.01
crude protein (%)	19.81 Aa	19.07 Cb	19.59 ABa	19.15 BCb	0.09
crude fat (%)	4.91	4.56	4.01	4.33	0.26
pH_1	6.27	6.41	6.41	6.38	0.38
pH_{24}	6.20	6.34	6.32	6.28	0.36

A, B, C – values in rows with different letters differ significantly, P≤0.01.
a, b, c – values in rows with different letters differ significantly, P≤0.05.

The analysis of basic components in meat showed significant differences (P≤0.05) in crude ash content of breast muscles and in dry matter and protein content of leg muscles (Table 4). The highest mineral content of breast muscles was in chickens fed wheat and maize diets as well as maize and triticale diets, whereas the lowest mineral content was found in birds fed wheat and triticale diets. The introduction of ground triticale into mixtures significantly reduced the dry matter content of leg muscles (P≤0.05), while the combination of wheat and triticale or the use of triticale alone decreased mainly the protein content of the muscles (P≤0.01). Despite the lack of significant differences in crude fat content of the analysed muscles, it was found that breast muscles from chickens fed maize and triticale diets contained more fat (by about 0.4 percentage units) compared to other birds. The opposite effect was observed in leg muscles.

There were no statistically significant effects (P>0.05) of feeding on pH of breast and leg muscles, measured 15 minutes after slaughter and after 24-hour chilling.

Apart from the basic components, it is also essential to analyse fatty acid profiles in meat lipids (Table 5). Diets used in the study significantly differentiated the content of each fatty acid and especially the acids with health-promoting qualities (DFA), in particular the linoleic ($C_{18:2}$) and linolenic ($C_{18:3}$) acids. Triticale as the only grain in mixtures caused a significant increase in the acid content compared to the groups receiving maize (M/W and M/T).

Table 5. Fatty acids (% of sum) of breast muscles

Item	Groups				SEM
	M/W	W/T	M/T	T	
$C_{14:0}$	0.08 ab	0.04 b	0.10 a	0.05 b	0.007
$C_{16:0}$	22.77 a	21.75 ab	22.62 a	21.09 b	0.31
$C_{18:0}$	5.81	5.52	5.72	5.82	0.39
$C_{18:1}$	30.27 a	29.34 ab	30.19 a	28.43 b	0.51
$C_{18:2}$	37.55 b	38.71 ab	37.41 b	39.07 a	0.69
$C_{18:3}$	1.38 b	1.82 ab	1.42 b	2.01 a	0.04
$C_{20:1}$	0.04 b	0.10 a	0.10 a	0.10 a	0.009
$C_{20:2}$	0.05 b	0.13 a	0.10 ab	0.13 a	0.01
$C_{20:3}$	0.04	0.05	0.05	0.05	0.005
$C_{20:4}$	0.45 a	0.33 ab	0.28 b	0.35 ab	0.009
SFA	28.72 a	27.56 ab	28.73 a	27.18 b	0.38
UFA	71.17 b	72.32 a	71.08 b	72.67 a	1.15
MUFA	31.70	31.28	31.82	31.06	0.89
PUFA	39.47 b	41.04 a	39.26 b	41.61 a	0.98
PUFA *n-6 : n-3*	27.21 a	21.27 ab	26.34 a	19.43 b	0.39
DFA	76.98 b	77.84 ab	76.80 b	78.49 a	1.16
OFA	22.85 a	21.79 b	22.72 a	21.14 b	0.31

DFA – neutral or hypocholesterolemic fatty acids ($C_{18:0}$ + UFA), OFA hypercholesterolemic fatty acids – ($C_{14:0}$ + $C_{16:0}$).

A, B – values in rows with different letters differ significantly, P≤0.01.

a, b – values in rows with different letters differ significantly, P≤0.05.

The analysis of meat quality traits includes not only its physico-chemical but also organoleptic characteristics (Table 6). Triticale as the only grain in mixtures did not have a negative effect on organoleptic characteristics of both breast and leg muscles. A positive influence of the combination of triticale and maize on breast meat juiciness, tenderness and flavour was found. These traits differed significantly (P≤0.05) between groups T/M and W/T.

Table 6. Sensory score of muscles of broiler chickens (points)

Item	Groups				SEM
	M/W	W/T	M/T	T	
Breast muscles					
flavour	4.39	4.11	4.32	3.96	0.15
juiciness	4.07	3.93	4.50	4.43	0.21
tenderness	4.36 ab	3.86 b	4.50 a	4.29 ab	0.14
palatability	4.29 AB	3.93 B	4.54 A	4.50 A	0.12
mean of trials	4.28 ab	3.96 b	4.47 a	4.30 ab	0.10
Thigh muscles					
flavour	4.57	4.25	4.21	4.38	0.16
juiciness	4.64	4.79	4.50	4.57	0.17
tenderness	4.64	4.64	4.43	4.71	0.14
palatability	4.64	4.50	4.50	4.71	0.17
mean of trials	4.63	4.54	4.41	4.59	0.16

A, B, C – values in rows with different letters differ significantly, P≤0.01.
a, b, c – values in rows with different letters differ significantly, P≤0.05.

Discussion

Studies concerning the application of triticale in broiler chicken diets have been carried out since the 1970s. Triticale has the most changeable chemical composition of all grains, which had an effect on the results obtained. Modern varieties of triticale have many positive characteristics. Therefore, it is reasonable to continue this research with particular emphasis on the effect of the grain on slaughter results and meat quality in broiler chickens. Different rearing indices in broiler chickens were obtained by other researchers who studied the effect of triticale on productive results compared to the results presented in this paper. Similarly to our study, Korver et al. (2004) showed significantly (P≤0.05) lower body weight (1972 g compared to 2096 g) and higher feed conversion ratio (1.88 kg compared to 1.72 kg per kg of live weight gain) in chickens fed triticale diets compared to wheat diets (P≤0.05). Józefiak et al. (2007) found the highest live weight gain in 35-day-old chickens fed triticale diets after using diets with only triticale, rye or wheat. Santos et al. (2008) also reported higher body weights in chickens fed triticale than maize diets, but the feed conversion ratio was similar in both groups (P>0.05). According to Vieira et al. (1995) and Zarghi and Golian (2009), the introduction of 40% of triticale into maize and soybean diets did not negatively affect body weight and feed conversion ratio in broiler chickens. Chapman et al. (2005) obtained similar body weights in chickens fed triticale diets (100% grains in mixture) and in birds from the control group. Moreover, the replacement of triticale with wheat did not reduce broiler body weights and did not increase feed conversion ratio (Matyka and Rubaj, 2004). Chickens from the control group were characterized by significantly better (P≤0.05) rearing performance than chickens fed maize and triticale diets or triticale diets, and the

EPI was higher by 64 and 69 points, respectively. Productive results were very good regardless of the grain combination in mixtures or the triticale content, because in a study by Matyka and Rubaj (2004) EPI values (about 265) were considerably lower than in our study irrespective of the type of grain in mixture.

The introduction of triticale into mixtures did not have any effect on dressing percentage despite higher body weights before slaughter in the control birds ($P \leq 0.05$). Likewise, Zarghi and Golian (2009) fed Ross 308 broilers a diet with different contents of triticale (0, 25, 50, 75, 100%) as a replacement of maize in the diet, but did not observe any differences between the groups. Triticale as the only cereal in mixtures significantly decreased breast muscle content, although Korver et al. (2004) stated slightly higher ($P > 0.05$) breast muscle content in chickens fed triticale diets compared to birds fed wheat diets.

Considering the classification presented by Trojan and Niewiarowicz (1971), pH_{15} is 5.9–6.2 in normal meat, lower than 5.7 in PSE meat and higher than 6.4 in DFD meat. Chickens from groups M/W and T had normal meat, while the other groups showed some symptoms of DFD (dark, firm, dry) meat. It is known, however, that meat acidity depends on many factors, not only on chicken genetic line (fast or slow growing) and feeding, but also on the preslaughter procedure. We found slightly better results with regard to meat acidity than those presented by Debut et al. (2003). The authors fed chickens with maize and wheat diets rather than triticale diets, and they only analysed the effect of chicken genetic lines and conditions before slaughter on meat pH. They showed that the average value of pH 15 minutes postmortem was 6.31–6.60 in breast muscles and was more consistent in leg muscles, in which it ranged from 6.56 to 6.60 regardless of the treatment factor.

The introduction of triticale or triticale and maize into diets for broiler chickens significantly decreased the economic indices during the rearing period. No statistically significant effects of the type of grain on dressing percentage and total muscle content in chilled carcasses were found. Triticale as the only grain in mixtures or in combination with wheat improved fatty acid profile in a way that provided greater health benefits.

The results obtained lead the authors to recommend the introduction of triticale into feed mixtures for broiler chickens. The grain does reduce production indices but it also positively affects meat quality, which is the most important consideration for consumers.

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Wpływ pszenżyta jako częściowego lub całkowitego zamiennika pszenicy i kukurydzy w mieszankach dla kurcząt brojlerów na wyniki odchowu, wartość rzeźną i jakość mięsa

STRESZCZENIE

Oceniano wpływ pszenżyta wprowadzonego do mieszanek dla kurcząt brojlerów jako zamiennika pszenicy, kukurydzy lub jako jedyne zboże, na wyniki produkcyjne i poubojowe oraz cechy fizykochemiczne i organoleptyczne mięsa. Wykazano, że zastosowanie ziarna pszenżyta w mieszankach dla kurcząt brojlerów wpłynęło na obniżenie ($P \leq 0,05$; $P \leq 0,01$) ich końcowej masy ciała (jako zamiennik pszenicy o 4%, a kukurydzy lub jako jedyne zboże o 8%) i zwiększenie odpowiednio o 8% i 14% zużycia paszy na jednostkę przyrostu. Rodzaj zboża nie miał istotnego ($P > 0,05$) wpływu na wydajność rzeźną i umięśnienie tuszki. Mięso kurcząt żywionych mieszankami zawierającymi samo pszenżyto lub pszenżyto z kukurydzą cechowało się podobnymi walorami smakowymi do mięsa kurcząt kontrolnych, natomiast połączenie pszenżyta z pszenicą wpłynęło na pogorszenie tych cech. Po zastosowaniu w mieszankach samego pszenżyta lub pszenżyta z pszenicą w lipidach mięśni piersiowych odnotowano istotną ($P \leq 0,05$) poprawę profilu kwasów tłuszczowych w kierunku prozdrowotnym.