INFLUENCE OF DIFFERENT AMOUNT OF WHOLE TRITICALE ON PRODUCTIVITY AND MEAT QUALITY OF BROILER CHICKENS

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Abstract. The trial was conducted to evaluate the effects of different dietary levels of whole triticale grains on broilers' productivity, carcass and fatty acids profile, sensory and texture properties of broilers meat. The trial with broiler chickens was carried out in an experimental poultry house of JSC "Vilniaus paukštynas" and poultry house of LUHS Veterinary Academy. 1000 *Ross 308* broiler chicks (one-day-old) were allocated to five treatment groups of 200 birds each in a randomized design. The treatment groups consisted of four replicates each of 50 chicks. Group I was control, other experimental ones. During their whole growing period broiler chickens of experimental group I were fed the diet containing 2% of whole triticale grains. Broiler chickens of experimental groups, depending on their age, were fed diets containing whole triticale grains from 4% to 8% in the initial growing stage, from 8% to 16% in the middle stage and from 15% to 25% in the final stage. Broiler chickens were reared up to 40 days old.

The trial results showed that whole triticale insertion to broiler chickens diets (at 35 days) reduced the body weight of chickens by 5–14%, compared to control group. Feed conversion ratio (kg/kg) (1–35 days) increased by 1–5% compared to control group (P>0.05). Insertion of different whole triticale to the diets increased the yield of muscle and yield of fat, SFA, n-6 and n-3 fatty acids ratio, compared to control group.

Keywords: broilers, whole triticale, poultry quality.

Introduction

Recently, many countries began to grow wheat and rye hybrids – triticale. Triticale can be one of the most valuable components for diets production. Triticale, compared with other grains, have better agro-technical features. It is one of the most fertile crop varieties resistant to diseases, undemanding in soil, and resistant to low temperatures, drought, moisture and other adverse conditions (Boros, 1999; Petraitis, Maikštėnienė, 2002; Milovanović, Perisic, 2002).

Triticale in animal feed is used as an energy source. Like other cereals, triticale is characterized by average protein content, high amount of starch and other carbohydrates and high overall energy content (Milovanović et al., 1998; 2005a; 2006).

The chemical and physical composition of triticale, depending on its varieties, differs minimally; the differences arise because of the growing region and the prevailing seasonal conditions. For this reason, there is no need to look for differences between triticale varieties in determining the chemical composition (Varughese et al., 1996).

In wheat and triticale non-starch polysaccharides are dominant – they have a rather high amount of arabinoxylan and β-glucan. These anti-nutritional factors in the digestive tract of birds cause disorder of the digestive processes. However, the above anti-nutritional substances in the poultry organism can be removed by using enzymes (Milovanović et al., 2005b). Hermes and Johnson (2004) conducted two studies to determine the nutritional value of triticale for broiler performance and productivity of laying hens. At the use of 5, 10 and 15% triticale in broiler diets, a substantial impact on the growth of broiler was not identified. Using 30% of triticale in the laying hens' diets the productivity remained unchanged compared with the control group (Hermes and Johnson, 2004). 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.

The use of triticale from 20% up to 69% in the broiler chicken diets has no negative effect on their growth, compared with the control group receiving only the corn. Recent findings were not so clear and in most cases showed no effect of grain on slaughter value and quality of poultry meat (Korver et al., 2004; Matyka, Rubaj, 2004; Józefiak et al., 2007; Santos et al., 2008).

Considering the conducted trials by the scientists Mahbub et al. (2011), it can be concluded that triticale-based diets, do not have a negative impact on the productivity parameters of the chickens. The growth of broiler chickens and carcass traits were better when triticale in the diets was 40 percent (Mahbub et al., 2011). However (Ruiz et al., 1987; Johnson, Eason, 1988; Al-Athari, Guenter, 1989; Vieira et al., 1995; Djekić et al., 2009a; Osek et al., 2010) determined different effects of triticale on the broilers' morphological carcass composition and quality of the meat.

So far, mainly the whole wheat has been used in broiler diets. The available data on the use of whole triticale in broiler diets and their impact on productivity and quality of the meat is rather scarce. Therefore, this trial was intended to investigate the influence of the whole triticale on chicken productivity, carcass and fatty acid composition and sensory and textural properties.

The aim of the trial was to evaluate the effects of different dietary levels of whole triticale grains on broilers‘ productivity, carcass morphological characteristics, fatty acids composition and sensory and texture properties of poultry.

Materials and methods

The scientific investigations were conducted following the provisions of the Republic of Lithuania (2012-10-03) for animal welfare and handling, Law No. IX - 2271 (Valstybės žinios, 1997, No. 108-2728; 2012, No. 122-6126) and a sub-statutory act by the State Food and Veterinary Service of Lithuanian Republic regarding the confirmation of the order on the animals for experiments, research, storage, maintenance and operating requirements (Valstybės žinios, 2012, No. 130-6595). The work was performed in accordance with EU Directive 2010/63/EU and the EC recommendation 2007/526 EC for Animal use and storage for experiments and other purposes.

The feeding trial was carried out with 1000 Ross 308 broiler chickens 1–40-day-old, divided into 5 groups. Each group was subdivided into 4 subgroups of 50 chickens, totalling 200 chickens per group.

Broiler chickens storage on a deep litter and drinking from automatic drinking nipples was according EU directive 2007/43/EC laying down minimum rules for the protection of chickens kept for meat production.

Five experimental diets were used in the study (Table 1) including one control diet and four diets containing from 2% to 25% whole grains of triticale.

Table 1. **The amount of whole triticale in the diets, %**

Period in days	Groups				
	Control	Experimental			
		I	II	III	IV
1–7	–	2	4	6	8
8–21	–	2	8	12	16
22–35	–	2	15	20	25
36–40	–	–	–	–	–

The birds were fed for 7 weeks *ad libitum* with a standard wheat-soybean meal compound diet (Control group) supplemented with 2% of whole triticale grains (I experimental group, from 1 to 35 old days), with 4–8% of whole triticale grains (II, III, IV experimental groups, from 1 to 7 old days), with 8–16% of whole triticale grains (II, III, IV experimental groups, from 8 to 21 old days) and with 15–25% of whole triticale grains (II, III, IV experimental groups, from 22 to 35 old days). From 36 to 40 days of age, all groups of chickens were fed the standard basal diet without the use of whole triticale and coccidiostatic. The diets were formulated to meet the nutrient and energy requirements for broiler chickens (NRC, 2004).

During the feeding trial, body weights at the age of 1, 7, 2l, 35 and 40 days, feed conversion ratio of each subgroup at the ages of 1–7 , 8–21, 22–35, 36–40 days, and birds mortality over the feeding trial were tested.

At the end of the trial (40 days old), from each group 5 broiler chickens (5 birds x 5 groups of birds = total of 25 birds) were selected and killed according to the recommendations for euthanasia of experimental animals (Close et al., 1997).

Carcass meat characteristics were evaluated according to Dissection of Poultry Carcasses, INRA (2000).

Extraction of lipids for fatty acid analysis was performed with chloroform/methanol (2:1 v/v) as described by Folch et al. (1957). Fatty acid methyl esters (FAME) were prepared using the procedure of Christopherson and Glass (1969). The FAMEs were analysed using a gas liquid chromatograph (GC – 2010 SHIMADZU) fitted with flame ionization detector. The relative proportion of each fatty acid was expressed as the relative percentage of the sum of the total fatty acids. Each sample was analyzed twice. Lipid quality indices, i.e., atherogenic index (AI) and thrombogenenicity index (TI), were calculated according to Ulbricht and Southgate (1991).

$$AI = [C12:0 + (4 \times C14:0) + C16:0] / [n\text{-}6\ PUFA + n\text{-}3\ PUFA + MUFA];$$

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

A sensory panel for the descriptive analysis was composed of 6 assessors experienced in sensory evaluation of poultry. The assessors were selected and trained according to the international standards ISO 8586-1[1] ([1]ISO 8586. General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors). The evaluation was closed out and conducted in accordance with ISO 8589[2] ([2]LST ISO 8589. Sensory analysis - General guidance for the design of test rooms) standards in a climate-controlled Sensory Analysis Laboratory equipped with individual booths. The samples were quartered lengthwise and served immediately to panellists along with room temperature water, tea and white bread for neutralization of receptors. The assessors were instructed to clean the palate with water or tea between evaluations of each sample.

Texture profile analyses of raw and boiled broiler chicken meat were performed using a Universal Testing Machine 3343 (Instron Engineering Group, High Wycombe, UK) equipped with a 1kN load cell and Bluehill software. The samples, measuring 2.0×2.0×2.0 cm, were compressed perpendicularly using a 50 mm diameter cylindrical probe. The testing conditions were two consecutive cycles at 50% compression, cross-head movement at a constant speed of 1 mm/s.

Raw meat samples for hardness tests were carried out at the same texture analyzer, using the Warner Bratzler knife, according to the methodology (Lyon, 2004).

Instrumental colour measurements of both raw and cooked meat were performed using the spectrophotometer GBC Cintra 202, calibrated throughout the study using the reference illuminant C, which is close to the average radiation daylight. The measurements were averaged and colour for each sample was expressed in terms of CIELAB values for L* (light/dark), a*(red/green) and b*(yellow/blue). The result stated for each sample is the mean value ± S. D. of 3-5 measurements.

Cooking loss (CL) of the meat samples was determined 20 hours after slaughter, according to the methodology proposed by (Kouba, 2003). The raw meat samples after weighing and packing in cooking bags were cooked at 100°C for 20 minutes. After this procedure, the samples were cooled at room temperature and weighed again. CL were calculated as a percentage and calculated as (initial weight-final weight) / (initial weight)*100.

Statsistical evaluation. SPSS software, version 15.0 (SPSS, Chicago, IL, USA) was used for statistical analysis of sensory analysis and texture instrumental measurements results. The analysis of variance was used to determine if significant differences existed among means when the impact of storage time had been evaluated. The differences were classified by Duncan multiple comparison test. Statements of statistical significance were based on $P<0.05$.

Results and discussion

By analyzing the body weight results at day 35 of life (Table 2) it was observed, that addition of different amounts of whole triticale reduced the weight of broiler chickens in the group I (2% whole triticale grain) by 5% lower ($P<0.05$) while in the remaining groups (whole triticale grain 15–25%) it decreased by 9–14% ($P<0.05$) compared with the control group. The negative tendency was also observed for feed conversion ratio (FCR), but the data are insignificant. Similar results were obtained by Osek et al. (2010), who found that birds fed whole wheat and whole triticale diets had the lowest body weight and higher FCR. According to Zarghi and Golian (2009), the introduction of 40% of triticale into diets did not negatively affect body weight and feed conversion ratio in broiler chickens. The analysis of broiler chickens liveability results (Table 2) showed that during the growth period of 1–35 days feeding with whole triticale grain did not significantly influence liveability. Analogous results were obtained by Korver et al. (2004), who found that compound feed supplemented with triticale had no significant influence on the mortality of broiler chickens.

Table2. **Effect of whole triticale grain on broiler chickens productivity and liveability**

Chickens age in days	Groups				
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
Body weight, g					
35	2439.3±19.17 ^{a} *100*	2325.0±17.14 ^{b} *95*	2216.3±21.35 ^{b} *91*	2103.2±20.38 ^{b} *86*	2107.2±20.78 ^{b} *86*
Feed conversion ratio, kg/kg					
1–35	1.78±0.17 *100*	1.80±0.13 *101*	1.84±0.15 *103*	1.81±0.03 *102*	1.87±0.13 *105*
Liveability, %					
1–35	92.5	93.5	93.5	93.5	93.0
a, b – mean values within each row with different superscripts are different at $P<0.05$					

Carcass yield of broiler chickens (Table 3) in the experimental groups tended to decrease from 0.89 to 3.18% compared with the control group ($P>0.05$).

The analysis of the results of broiler breast muscle yield showed that the insertion of whole triticale grain in broiler diets from 15% to 25% improved the breast muscle yield by 0.29% and 0.47% respectively, compared with the control group ($P>0.05$). At insertion of 2% whole triticale grain in the diet (1–35 d of age), this index decreased by 0.15% and at insertion of 20% of whole triticale the breast muscle yield decreased by 1.12%, compared with the control group ($P>0.05$).

The yields of broiler chickens' leg muscle and fat of treatment groups II, III and IV had a tendency to increase. The yield of leg muscle in these groups increased from 0.74 to 1.82% and abdominal fat yield from 0.68 to 0.73%, compared with the control group ($P>0.05$).

Table 3. **Effect of whole triticale grain on broiler chickens carcass yield** (%)

Parameter	Groups				
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
Carcass yield	75.18±2.17	72.18±0.82	72.00±0.79	74.29±0.98	72.96±0.52
Breast muscle yield	25.19±0.66	25.04±1.57	25.48±1.06	24.07±0.88	25.66±0.82
Legs muscle yield	19.08±0.76	17.86±1.16	19.82±0.84	20.26±0.78	20.90±0.69
Abdominal fat yield	0.86±0.27	0.85±0.10	1.59±0.19	1.57±0.16	1.54±0.31

The individual fatty acid profiles in the breast muscle fat of broiler chickens are shown in Table 4. The contents of miristic acid (C14:0), palmitic acid (C16:0) and palmitoleic acid (C16:1) in fat of breast muscle were relatively higher in chicken of groups II, III and IV. These increases were caused by oils presented in the diets. The content variations of hexadecenoic (16:1) acid, stearic acid (C18:0), vakenic acid (18:1 n-9 trans) and eicosadienoic acid (20:2 n-6) give no evident trend. Percentages of other fatty acids in experimental groups were lower than in control group, but these differences were not significant.

Table 4. **Percentages of fatty acids in chickens' breast fat** (%)

Fatty acids	Groups				
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
C14:0	0.32 ± 0.02	0.30 ± 0.03	0.66 ± 0.21	0.67 ± 0.32	0.37 ± 0.06
C15:0	0.16 ± 0.04 ^{a}	0.29 ± 0.04 ^{ab}	0.21 ± 0.09 ^{ab}	0.10 ± 0.01 ^{ab}	0.29 ± 0.03 ^{b}
C16:0	18.90 ± 0.41	19.00 ± 0.51	22.05 ± 1.86	19.79 ± 0.22	21.34 ± 0.57*
C16:1 n-7	0.52 ± 0.03	0.49 ± 0.03	0.47 ± 0.05	0.58 ± 0.03	0.52 ± 0.03
C16:1 n-9	2.97 ± 0.42	2.39 ± 0.10	3.01 ± 0.29	5.33 ± 1.10	3.03 ± 0.44
C18:0	6.16 ± 0.47	6.82 ± 0.48	7.26 ± 0.35	4.78 ± 0.33	7.00 ± 0.46
C18:1 n-9 trans	0.54 ± 0.09	0.46 ± 0.04	0.42 ± 0.06	0.33 ± 0.02	0.36 ± 0.05
C18:1 n-9 cis	38.33 ± 2.44	36.69 ± 1.07	39.89 ± 0.94	41.36 ± 0.50	36.09 ± 2.37
C18:1 n-7	2.91 ± 0.15	2.97 ± 0.20	2.75 ± 0.17	2.77 ± 0.10	3.19 ± 0.11
C18:2 n-6 trans	0.49 ± 0.14	0.42 ± 0.08	0.24 ± 0.08	0.26 ± 0.05	0.28 ± 0.10
C18:2 n-6	17.73 ± 0.84	18.66 ± 0.93	15.61 ± 0.26	16.21 ± 0.87	15.99 ± 1.30
C18:3 n-3	2.16 ± 0.17	2.07 ± 0.26	1.61 ± 0.35	1.95 ± 0.13	1.65 ± 0.12
C20:1 n-9	0.49 ± 0.03 ^{a}	0.49 ± 0.02 ^{ab}	0.63 ± 0.02 ^{b}	0.48 ± 0.02 ^{ab}	0.56 ± 0.04 ^{ab}
C20:2 n-6	0.41 ± 0.10	0.43 ± 0.04	0.36 ± 0.06	0.30 ± 0.03	0.42 ± 0.10
C20:3 n-6	0.61 ± 0.17	0.56 ± 0.08	0.38 ± 0.06	0.33 ± 0.05	1.04 ± 0.32
C20:4 n-6	2.33 ± 0.46	2.87 ± 0.23	1.32 ± 0.40	1.44 ± 0.23	2.81 ± 0.63
C22:1 n-9	0.42 ± 0.14	0.30 ± 0.07	0.35 ± 0.11	0.22 ± 0.04	0.56 ± 0.20
C22:4 n-3	0.53 ± 0.13	0.63 ± 0.11	0.28 ± 0.09	0.30 ± 0.05	0.53 ± 0.15
C22:5 n-3	1.05 ± 0.28	1.24 ± 0.14	0.62 ± 0.20	0.60 ± 0.08	1.17 ± 0.21
C22:6 n-3	0.65 ± 0.16 ^{a}	0.78 ± 0.06 ^{ab}	1.60 ± 0.45 ^{b}	1.73 ± 0.28 ^{ab}	2.22 ± 054 ^{b}
a, b – mean values within each row with different superscripts are different at P<0.05					

Table 5. **The influence of whole triticale on the broiler chickens' breast muscle fat quality**

Fatty acids	Groups				
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
∑ SFA, %	25.74 ± 0.76	26.68 ± 1.03	30.62 ± 2.35	25.64 ± 0.37	29.37 ± 0.78
∑ MUFA, %	46.40 ± 2.58	44.00 ± 0.97	47.68 ± 1.25	51.40 ± 0.28	44.53 ± 2.48
∑ PUFA ,%	26.54 ± 1.91	28.19 ± 0.90	20.99 ± 1.15	22.28 ± 1.10	25.05 ± 2.47
∑ PUFA / ∑ SFA	1.03 ± 0.07 ^{a}	1.06 ± 0.06 ^{ab}	0.70 ± 0.08 ^{b}	0.87 ± 0.04 ^{ab}	0.86 ± 0.09 ^{ab}
∑ n-3, %	4.39 ± 0.48	4.72 ± 0.11	2.79 ± 0.69	3.30 ± 0.09	3.95 ± 0.47
∑ n-6, %	21.67 ± 1.38 ^{a}	23.01 ± 0.85 ^{ab}	17.95 ± 0.37 ^{b}	18.66 ± 1.02 ^{ab}	20.61 ± 2.03 ^{ab}
∑(n-6)/ ∑(n-3)	5.01 ± 0.24	4.88 ± 0.19	8.04 ± 2.98	5.65 ± 0.19	5.28 ± 0.31
AI	0.28 ± 0.01 ^{a}	0.28 ± 0.01 ^{ab}	0.36 ± 0.05 ^{ab}	0.31 ± 0.02 ^{ab}	0.33 ± 0.01 ^{b}
TI	0.54 ± 0.02 ^{a}	0.55 ± 0.03 ^{ab}	0.74 ± 0.12 ^{ab}	0.56 ± 0.01 ^{ab}	0.65 ± 0.03 ^{b}
a, b – mean values within each row with different superscripts are different at P<0.05					

The content of saturated fatty acids (SFA) in the breast muscle of broiler chickens in all experimental groups except group III increased from 0.94% to 4.88% compared with the control group (Table 5). SFA content in the breast muscle fat of broiler chickens from experimental group III (added whole triticale 20%) was by 0.1% lower compared with the control group (P>0.05).

The content of monounsaturated fatty acids (MUFA) in experimental groups II and III (inserted whole triticale 15% and 20%) were higher by 1.28% and 5.0% respectively compared with the control group. MUFA percentage of chicken breast muscle decreased by 2.40% and 1.87% compared with control group when 2% and 25% of whole triticale was added to broiler chicken diets respectively during the growing period (P>0.05).

The content of polyunsaturated fatty acids (PUFA) in the breast muscle was influenced by diets with the increased amount of whole triticale (15% to 25%). PUFA percentage of experimental groups decreased from 1.49% to 5.55% compared with control group. PUFA content in chicken breast muscle increased by 1.65% compared with control group when broiler chicken diets were enriched by 2% whole triticale during the growing period (P>0.05).

The diet with increased amount of whole triticale (experimental groups II–IV) produced a marginal increase in the ∑(n-6) / ∑(n-3) ratio. Insertion of whole triticale in the diets increased intramuscular fat quality criterions, such as atherogenic index (AI) and thrombogenic index (TI). There were no significant effects of diet in I, II and III experimental groups (P>0.05). AI and TI were significantly increased in broilers fed diet with 25% of whole triticale (Table 5, IV experimental group) compared with the control group (P<0.05). This effect is unfavourable for broiler meat consumers.

The effect of whole triticale amount in feed on sensory quality of broiler chicken breasts assessed by a trained panel is shown in Table 6. No significant differences were found between samples for the sensory attributes of odour (P>0.05). All samples were described as having clear typical odour of boiled chicken meat. No correlation between amount of added whole triticale and intensity of non typical odour could be established.

Table 6. **Effect of whole triticale amount in feed on breast meat sensory properties and acceptability**

Sensory attribute	Groups				
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
Overall odour intensity	7.8	7.9	8.3	7.8	7.9
Boiled chicken odour	7.5	7.6	7.8	7.0	7.6
Non typical odour	1.0	1.0	1.0	1.1	1.3
Color intensity	2.9^{a}	3.0^{a}	3.0^{a}	4.2^{b}	3.4^{a}
Hardness	3.4^{a}	3.4^{a}	3.9^{ab}	4.4^{bc}	4.9^{c}
Fibre	4.0^{a}	3.6^{a}	4.6^{ab}	5.6^{b}	5.5^{b}
Juiciness	5.4	5.8	4.9	5.8	6.0
Chewiness	5.1	5.0	5.6	6.2	5.9
Crunchiness	4.2	4.4	5.0	5.1	5.0
Overall taste intensity	8.0	8.0	7.9	7.7	8.0
Boiled chicken taste	7.7	7.8	7.9	7.4	7.6
Non typical taste	1.3	1.0	1.1	1.2	1.2
Mouthfeel	1.6	1.5	1.4	1.8	1.6
Aftertaste	3.4	3.1	3.4	3.6	3.6
Overall acceptability	7.7	7.9	7.5	7.0	7.1
a, b, c – mean values within each row with different superscripts are different at P<0.05					

Table 7. **Effect of whole triticale amount in feed on thigh meat sensory properties and acceptability**

Sensory attribute	Groups				
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
Overall odour intensity	7.9	8.0	8.0	7.7	7.7
Boiled chicken odour	7.6	7.6	7.9	7.7	7.5
Non typical odour	1.1	1.0	1.2	1.1	1.0
Color intensity	5.2	4.8	5.1	5.3	5.4
Hardness	3.2	3.7	3.7	3.6	4.0
Fibre	3.0	3.6	3.6	3.6	3.5
Juiciness	6.2	6.2	6.2	5.4	5.4
Chewiness	5.0	5.1	5.2	5.4	5.2
Crunchiness	4.0	4.5	4.1	4.5	3.6
Overall taste intensity	7.6	7.8	7.9	7.7	7.9
Boiled chicken taste	7.4	7.6	7.8	7.6	7.6
Non typical taste	1.2	1.1	1.1	1.1	1.1
Mouthfeel	5.6	5.0	4.9	4.8	4.7
Aftertaste	5.4	6.2	5.1	5.2	5.5
Overall acceptability	7.8	8.1	7.7	7.7	7.7

Sensory analysis of texture did not show effect of diet type on juiciness, crunchiness or chewiness (P>0.05) of breast meat. Hardness and fibre of meat increased (P<0.05) with increasing amount of added triticale. Clear difference in meat hardness was established at the moment when the amount of added triticale reached 20%.

Taste properties were not affected by addition of whole triticale to diet (Table 6).

Preliminary data of meat acceptability testing are presented in Table 6. Differences in sample texture properties were not too high to impact acceptability of texture. All samples were acceptable for consumers.

Amount of added triticale to feed had no significant effect (P>0.05) on sensory properties or acceptability of thigh meat (Table 7).

Mean values of cooking loss are presented in Table 8. No significant effect of amount of added whole triticale on water holding properties was determined for breast meat. A significant effect of feed composition on cooking loss for thigh meat was determined in our research. Cooking loss of control group samples was lower in comparison with samples when whole triticale was added to feed (P<0.05).

Feed composition had no significant effect on texture properties as is showed by instrumental analysis data (Table 9). Data from sensory analysis (Table 6) showed affect of feed composition on hardness, but it was not proved by instrumental method. The reason can be higher fibre of samples, which for sensory panel can be associated with higher hardness. When the amount of added whole triticale in the diet reached 20 %, more force was necessary to shear samples.

Color characteristics of fresh meat were not affected (P>0.05) by feed composition (Table 10).

Significant differences were determined in values of colour characteristics for boiled meat samples, but no clear effect of whole triticale amount in feed was determined. A possible explanation of differences can be related with other technological factor, such as a higher amount of blood in a sample.

Table 8. **Effect of whole triticale amount in feed on cooking loss of meat** (%)

Characteristic	Groups				
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
Breast meat	24.18^{a}	23.46^{a}	26.85^{a}	24.28^{a}	27.78^{a}
Thigh meat	28.75^{a}	32.99^{b}	34.45^{b}	37.39^{b}	38.49^{b}
a, b – mean values within each row with different superscripts are different at P<0.05					

Table 9. **Effect of whole triticale amount in the diet on texture properties of breast meat**

Characteristic	Groups				
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
Hardness, N	66.73	61.34	70.15	51.22	67.36
Cohesiveness, ratio	0.830	0.827	0.847	0.824	0.831
Springiness, mm	5.58	5.77	5.24	5.73	5.47
Chewiness	121.41	115.92	111.90	102.52	122.43
Hardness (WB value), N	18.3^{a}	17.4^{a}	18.19^{a}	21.15^{b}	20.99^{b}
a. b – mean values within each row with different superscripts are different at P<0.05					

Table 10. **Effect of whole triticale on chicken breast color characteristics**

Color characteristic					
	Control	Experimental I + 2% triticale	Experimental II + 15% triticale	Experimental III+ 20% triticale	Experimental IV + 25% triticale
Raw meat					
L*	58.79	60.25	58.86	61.96	62.79
a*	5.27	5.05	5.65	4.72	4.65
b*	2.09	3.23	2.67	1.94	2.82
Boiled meat					
L*	87.28^{c}	84.23^{a}	84.50^{ab}	86.85^{bc}	82.84^{a}
a*	2.47^{a}	3.34^{b}	2.96^{ab}	2.85^{ab}	2.43^{a}
b*	3.25^{b}	3.45^{b}	2.90^{b}	1.34^{a}	3.32^{b}
a, b, c – mean values within each row with different superscripts are different at P<0.05					

Conclusions

1. The addition of different amounts of whole triticale in the diets at day 35 of life reduced the weight of broiler chickens in group I by 5% ($P<0.05$) while in the remaining groups it was reduced by 9–14% ($P<0.05$) compared with the control group.
2. During 1–35 days of the testing period, FCR in the experimental groups was higher by 1–5% compared with the control group ($P>0.05$).
3. Whole triticale grain in the broiler chickens diets did not significantly influence liveability.
4. Carcass yield of broiler chickens in the experimental groups tended to decrease from 0.89 to 3.18% compared with the control group ($P>0.05$). However the yield of leg muscle in treatment groups II, III and IV increased from 0.74 to 1.82% and abdominal fat yield from 0.68 to 0.73%, compared with the control group ($P>0.05$).
5. The content of saturated fatty acids in the breast muscle of broiler chickens from all experimental groups, except group III, increased from 0.94% to 4.88%, monounsaturated fatty acids in experimental groups II and III (inserted whole triticale 15% and 20%) were higher by 1.28% and 5.0% respectively, the content of polyunsaturated fatty acids in the breast muscle increased by 1.65% compared with control group when broiler chickens diets were enriched with 2% of whole triticale during the growing period ($P>0.05$).
6. Atherogenic and thrombogenic indexes were significantly increased from 0.28 and 0.54 to 0.33 and 0.65 respectively by adding 25% whole triticale to feed of chicken.
7. Supplementation of feed by different amounts of whole triticale had no significant effect on taste and odour properties of meat. With increasing amount of whole triticale in feed sensory hardness and fibre increased, but it had no negative impact on acceptability.

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