THE APPLICATION OF TRITICALE IN NUTRITION OF BROILER CHICKENS

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Abstract. The objective of this work was to analyse the chemical composition of wheat and triticale varieties and their application in nutrition of broiler chickens. In the first step, grains of different varieties were analysed for chemical and amino acid composition; and later, the experiment with broiler chickens was performed. Birds were fed for 5 weeks with wheat (the variety *Zentos*) – soybean meal compound feed (Control group). In the compound feed of experimental diet (Group T), wheat *Zentos* was replaced by 15% of triticale variety *SU Agendus*. The intestinal content of *Duodenum*, *Intestinum tenue*, *Cecum* and *Intestinum crassum* was collected for the determination of pH and DM content. The concentration of chymus SCFA was measured by the HPLC system. It was found that the mean level of crude protein was 11.44% DM in wheat variety *Zentos,* the mean amount of crude fat was 1.28% DM and crude fibre 1.88% DM. In triticale variety *SU Agendus*, the mean level of crude protein was 11.57% DM, the mean amount of crude fat 1.30% DM and crude fibre 1.35% DM. Triticale showed levels of NDF – 10.04% DM, ADF – 2.50% DM, and ADL – 1.02% DM. In addition to 15% of triticale in the compound feed of broiler chickens, the concentration of acetic and propionic acids increased by 6% and 16%, respectively. The DM of *Intestinum crassum* increased significantly by 6% compared with the C group ($P<0.05$). In the compound feed of broiler chickens, up to 15% of wheat could be replaced by triticale without affecting performance and digestive processes of broilers.
Keywords: chemical composition, broiler chickens, nutrition, triticale, physiology

Introduction. Triticale (X *Trificosecule* Wittmack) is the hybrid of wheat (*Triticum aestivum* L) and rye (*Secale cereale* L) that has been under intensive development as a new cereal grain crop plant (Korver, 2004). Triticale has demonstrated high yield potential even under marginal growing conditions and could be a very attractive alternative for raising cereal production globally. It can be grown in poor soils, giving high yield where wheat does not perform well. Triticale is mainly used as an ingredient in animal feed. Triticale is a relatively new feed grain and little used in poultry nutrition, because one of the primary reasons is that there is apparently a fair amount of variation in the nutrient content of different varieties of triticale (Hermes, Johnson, 2004).

Poultry diets are typically composed primarily of corn and soybean meal. Triticale is a convenient feed for all animals representing a high source of energy (Đekić et al., 2011). The consumption of triticale depends on its highly variable chemical composition and is more similar to wheat than rye. The protein content of triticale lines has ranged from 10% to 20% on a dry weight basis, which is higher than wheat (Myer, 2002; Boros, 2002). The amino acid composition of protein is similar to wheat, but may be slightly higher in lysine (Đekić et al., 2012a) and the high dietary fibre in triticale. Hermes and Johanson (2004) and Đekić et al. (2012b) suggest that triticale in animal feed mixtures does not have negative consequences on the growth of domestic animals. Triticale is a convenient feed for all animals since it represents a high source of energy. Because of favourable enzyme composition, triticale grains favourably affect the intestinal tract of monogastric animals (Barneveld and Cooper, 2002; Korver et al., 2004).

Some studies have shown no deteriorating effect on productivity of broilers and/or layers when the diet's grain portion consisted of 100% triticale (Chapman et al., 2005). Karaalp and Ozsoy (2001) also reported that more than 30% of triticale in broiler diets has reduced yield performance and efficiency and has not improved even when enzyme was added to triticale.

The aim of this work was to analyse the chemical composition of wheat and triticale varieties and their application in nutrition of broiler chickens and to evaluate feed conversion and gastrointestinal pH of broiler chickens as well as concentration of short-chain fatty acids in broiler chickens fed diets containing 15% of triticale variety *SU Agendus*.

Material and methods. Sample collection and preparation. Variety *Zentos* of wheat and variety *SU Agendus* of triticale were collected from Kaunas Plant Variety Testing Station (PVTS). Fertilisation of triticale and wheat was applied as $N_{11}P_{22}K_{55}$ and, additionally, $N_{68.8}$+$N_{68.8}$, and the following parameters of the soil were humus 1.65%, pH 7.6, P_20_5 140 mg kg^{-1}, K_20 327 mg kg^{-1}.

Chemical analysis. Grain samples were taken and analysed in accordance with the Commission regulation (EU) No 691/2013 of 19 July 2013 amending Regulation (EC) No 152/2009 as regards methods of sampling and analysis. Grain samples with 3 subsamples for chemical analyses were ground in an Ultra Centrifugal Mill model ZM 100 (Retsch GmbH, Germany) with 1.0 mm sieve. Dry matter yield of grain was determined by drying the sample in an oven at 105 ºC until constant weight was obtained. Crude protein content was determined by the Kjeldahl method, and conversion factors of 5.7 for wheat and 6.25 for triticale were used to convert total nitrogen to crude protein. Crude fat was extracted with petroleum ether (boiling range of 40−60 °C) by the Soxhlet extraction method. Crude ash was determined by incineration in a muffle furnace at 550 °C for 3 h (Commission Regulation (EC) No. 152/2009). Crude fibre was determined as the residue after sequential treatment with hot H_2SO_4 (conc. 1.25%) and hot NaOH (1.25%) according to the Weende method. The samples were subjected to the fibre component analyses for ANKOM 220 Fiber Analyzer (ANKOM Technology, USA): acid detergent fibre (ADF) and neutral detergent fibre (NDF), acid detergent lignin (ADL) using a cell wall detergent fractionation method according to van Soest (Faithfull, 2002). Nitrogen-free extract (NFE) was calculated as follows: NFE (%) = 100 − (moisture % + crude protein % + crude fat % + crude ash % + crude fibre %).

Experimental design. Four hundred one-day-old Ross 308 broiler chicks were randomly allocated to 2 treatments. All chickens had *ad libitum* access to compound feed and clean water throughout the experiment. The birds were fed for 5 weeks with wheat (variety *Zentos*) – soybean meal compound diet in the control group (group C). In the compound feed of the experimental diet, wheat *Zentos* was replaced by 15% of triticale variety *SU Agendus* in the experimental group (Group T). The composition and calculated values of the basal diet are shown in Table 1. The basal diet was formulated to meet the nutrient and energy requirement for broiler chickens (NRC, 1994).

Crude fat of compound feed by ether extraction was analysed; crude fibre was determined as the acid and alkali–insoluble nitrogen–free extractives residue. The analysis of the calcium content: calcium compounds in crude ash were treated with hydrochloric acid; the resulting calcium precipitated as calcium oxalate; the residue was dissolved in sulfuric acid, and the oxalic acid solution was titrated with potassium permanganate solution. Phosphorus was determined by the photometric method. Crude protein was analysed by the Kjeldahl method (Pašarų tyrimo metodai, 2003; Mikulionienė, 2000).

Table 1. **Composition and calculated values of the compound feed**

Ingredients	C (Control) group	T (15% triticale) group
	Components (%)	
Wheat *Zentos*	50.42	34.18
Soybean meal	30.00	29.95
Triticale *SU Agendus*	–	15.00
Corn	10.00	10.00
Plant oil	3.44	4.75
Fatty acid mix	1.50	1.50
Limestone	1.09	1.10
Fish meal	2.00	2.00
Monocalcium phosphate	0.73	0.71
Premix[1]	0.50	0.50
Sodium chloride	0.18	0.18
Natrium sulphate	0.14	0.13
	Calculated values, %	
ME (metabolized energy), MJ/kg*	13.08	13.08
Crude protein*	21.00	21.00
Crude fat*	7.01	8.21
Crude fibre*	2.52	2.50
Crude ash*	5.59	5.56
Calcium (Ca) *	0.90	0.90
Phosphorus (P) *	0.61	0.61
Av. phosphorus	0.40	0.40
Sodium (Na)	0.16	0.16
Magnesium (Mg)	0.08	0.08
Potassium (K)	0.94	0.94

[1]Premix composition: vit. A – 12.000 IU, vit. D_3 – 5.000 IU, vit. E – 90 mg/kg, vit. K_3 – 3.50 mg/kg, vit. B_1 – 2.50 mg/kg, vit. B_2 – 8.00 mg/kg, vit. B_6 – 5.00 mg/kg, vit. B_{12} – 29.98 µg/ kg, nicotinic acid – 55.00 mg/kg, pantothenic acid– 15.00 mg/kg, folic acid – 1.75 mg/kg, biotin – 149.99 µg/kg, cholin chloride – 399.00 mg/kg, choline – 2043.86 (C group) and 1934.57 (T group) mg/kg, Mn – 112.50 mg/kg, Fe – 39.99 mg/kg, Zn – 99.97 mg/kg, Cu – 16.00 mg/kg, I – 1.98 mg/kg, Se – 0.32 mg/kg, Antioxidant Etoksikvin – 66.10 mg/kg.

Records for live body weight (BW) and feed consumption were obtained at the end of each period, and feed conversion ratio (FCR) was calculated. At the end of the trial (35 days), 5 broiler chickens (5 birds × 2 groups of birds = total of 10 birds) were selected from each group and euthanised according to the recommendations for euthanasia of experimental animals (Close et al., 1997). The intestinal content from duodenum *(Duodenum)*, small intestine *(Intestinum tenue)*, caeca *(Cecum)* and rectum *(Intestinum crassum)* was collected for the determination of pH and dry matter content. In the remaining cecum content, short-chain fatty acids (SCFA) were determined.

pH was measured with pH-meter Inolab pH 730 (WTW, Germany); content of dry matter was determined by drying the chyme at 105 °C until total desiccation and calculating the difference between the dried and non-dried contents of the intestinal sections. For the SCFA analysis, 0.20–0.50 g of the sample (weighing accuracy of four decimal places) was weighed into conical tubes, flushed with 2 mL of distilled water, and the tube was continuously vortexed for 1 min by MS2 Minishaker (IKA Works, Inc.) at 1800–2200 rpm/min. After mixing the tubes with samples, they were allowed to stand for 1–2 hours. Dropwise 0.05 mL of 30% zinc sulphate ($ZnSO_4 * 7H_2O$) and 15% potassium ferocyanide ($K_4 [Fe (CN)_6] * 3H_2O$) was added. The tubes were vortexed for 1 min and then allowed to stand for 1 h. After that, the samples were centrifuged 4000 ×g for 20 min, and the resulting solution was filtered through a membrane filter. Prevail organic acid column (250x4.6 mm, 5u; Grace Davison Discovery Sciences, USA), with an injection volume of 10 µL, wavelength 210 nm, a mobile phase of 25 mM KH_2PO_4 (pH 2.5): MeOH (80:20), and the flow rate 1.20 mL/min was employed. The concentration of SCFA was measured by the HPLC system (Varian Inc., USA) (Kliseviciute et al., 2014).

Statistical analysis. Statistical significance was established using one-way analysis of variance (ANOVA), and the data were reported as the mean of standard deviation. Mean comparison and separation were done using the Duncan *t* test ($P<0.05$). ANOVA was conducted using the statistical package SPSS 22.

Results and discussion

The chemical composition and concentration of amino acids of wheat variety *Zentos* and triticale variety *SU Agendus* are presented in Table 1. The results of chemical analysis showed that the crude protein content in wheat variety *Zentos* was 11.44% DM and in *SU Agendus* variety it was a little higher, i.e. 11.57% DM.

Table 1. **Chemical and amino acid composition of triticale and wheat grain (87% dry matter)**

Parameters	Chemical composition of the cereals (%)	
	Wheat *Zentos*	Triticale *SU Agendus*
Crude protein	11.44	11.57
Crude fat	1.28	1.30
NFE	71.38	71.25
Crude ash	1.02	1.53
Crude fibre	1.88	1.35
NDF	11.67	10.04
ADF	3.49	2.50
ADL	1.16	1.02
	Concentration of amino acids in the cereal grains (g kg^{-1})	
Lys	3.09	2.81
Met	0.93	0.84
Thr	3.30	2.86
Ile	4.15	3.11
Val	4.93	4.12
Leu	7.92	6.85
His	3.85	3.59
Phe	5.09	3.95
Tyr	3.23	2.52
Arg	7.39	5.77
Asp	5.90	6.16
Ser	5.23	4.03
Glu	37.85	24.43
Pro	11.23	8.09
Gly	5.20	4.43
Ala	4.12	3.58

The amount of crude fat in the analysed variety of triticale was higher by 0.20% DM, compared with the wheat variety. The highest content of NFE was determined in the *Zentos* variety. Triticale contained lower concentrations of crude fibre.

The mean amount of NDF, ADF and ADL in the analysed triticale variety was lower than in the wheat variety. Kowieska et al. (2011) analysed 7 winter triticale varieties and found that crude protein was 11.70%, fibre 2.64%, crude ash 1.82%, and NFE 82.26%. The results are fairly typical for triticale and wheat and are comparable with those reported by Rodehutscord et al. (2016) and Kliseviciute et al. (2014).

However, some differences in the composition of amino acids were observed, particularly in glutamic acid. Triticale variety *SU Agendus* was slightly lower in lysine and higher in aspartic acid than in wheat variety *Zentos*. The lower concentration of total amino acids was determined in triticale variety *SU Agendus* (87.14 g kg^{-1}) and higher in *Zentos* (113.41 g kg^{-1}).

Table 2 shows the data of body weight and feed conversion ratio (FCR) during the whole (1–35 days) experimental period. The results of the present study showed that FCR did not differ statistically significantly among the treatment groups (P>0.05).

Table 2. **The effect of triticale inclusion in compound feed on productivity of broiler chickens**

Body weight			Feed conversion ratio		
Broiler chicken age in days	C (Control) group	T (15% triticale) group	Period in days	C (Control) group	T (15% triticale) group
35	2658.79±286.34	2647.63±234.53	1–35	1.51±0.03	1.55±0.03

Inclusion of 15% of triticale in broiler diets did not affect body weight in comparison with the control group. Similar results were found in other studies. Body weight of chickens fed with inclusion of triticale in the compound feed is not different from the values obtained in feeding broilers with wheat (Korver et al., 2004). However, as the data obtained by Moharrery et al. (2015) indicate, triticale has a great potential as feed for chickens because body weight of broilers in the group using triticale increased. Jøzefiak et al. (2007) and Santos et al. (2008) also reported higher body weights in chickens fed triticale than diets with only triticale, rye or wheat.

The results of *Cecum* SCFA concentrations of broiler chickens are shown in Table 3. The replacement of 15% triticale in the diet significantly decreased only butyric acid concentration by 30% (P<0.05). The quantity of the rest SCFA (acetic and propionic acids) was increased by 6% and 16%, respectively. These results showed that grains of triticale acted as prebiotics in the digestive tract of broiler chickens, because SCFA is a major product of prebiotic breakdown.

Table 3. **Effect of triticale inclusion in compound feed on SCFAs in the *Cecum* of broiler chickens (µmol/g)**

Parameters	C (Control) group	T (15% triticale) group
Acetic	85.97±28.73	91.14±10.38
Propionic	17.22±3.11	19.92±4.98
Butyric	32.81±21.37[a]	23.08±7.62[b]
[a, b] Means within a row with different superscripts differ significantly (P<0.05)		

Table 4. **Effect of triticale inclusion in compound feed on pH value and DM content in the digesta of different parts of broiler chickens' gastrointestinal tract**

Segments of gastrointestinal tract	C (Control) group	T (15% triticale) group
	Dry mater, %	
Duodenum (*Duodenum*)	17.51±1.38	15.46±1.80
Small intestine (*Intestinum tenue*)	16.44±4.00[a]	14.63±1.32[b]
Caeca *(Cecum)*	17.42±5.45	17.26±0.00
Rectum *(Intestinum crassum)*	13.19±5.71[a]	19.15±1.21[b]
	pH	
Duodenum (*Duodenum*)	5.55±0.41	5.81±0.22
Small intestine (*Intestinum tenue*)	5.73±0.76	5.07±0.59
Caeca *(Cecum)*	6.40±0.25	6.04±0.00
Rectum *(Intestinum crassum)*	6.06±0.80	5.21±0.36
[a, b] Means within a row with different superscripts differ significantly (P<0.05)		

Józefiak et al. (2007) analysed the influence of triticale on the gastrointestinal tract of broiler chickens and found that *cecum* contents, lactic acid concentration and concentrations of butyrate increased after the addition of enzyme to the triticale-based diet. This is consistent with previous reports which show that acetic acid production starts early (Lan et al., 2005). In the current experiment, we observed differences in concentrations of SCFA between broiler chicks. Previous reports have shown that a relatively longer intestinal length in broiler chicks could contribute to a difference in SCFA concentration.

The effects of 15% of triticale in the diet of broiler chickens on the dry matter (DM) content and chymus pH of different gastrointestinal tract segments are shown in Table 4.

The DM of *Intestinum crassum* significantly (by 6%) increased compared with Group C (P<0.05). However, there were no significant differences in different segments of gastrointestinal tract pH of the experimental group. The change in the pH in the *Duodenum* and other gastrointestinal segments may be due to the effects of the diets on secretion of gizzard hydrochloric acid by the *Proventriculus*. The reduction in pH of the gizzard is considered as an effective means to prevent potentially pathogenic bacteria. Kliseviciute et al. (2014) analysed triticale grain (2–25%) in broiler diet and found that triticale had no significant effect on pH and DM content of separate parts of the gastrointestinal tract.

Conclusions

In our study, it was determined that triticale variety *SU Agendus* accumulated higher levels of crude protein (mean 11.57 % DM) and crude fat (1.30% DM), but not crude fibre, compared with what variety *Zentos*. It was found that wheat replacement by 15% of triticale in the compound feed of broiler chickens had no significant influence on the productivity and feed conversion ratio. However, when triticale was used in the diet, the caecal butyric acid content decreased. The inclusion of the whole triticale up to 15% in the compound feed of broiler chickens had no significant negative impact on the productivity and intestinal physiology of broiler chickens.

Variety *SU Agendus* of triticale grown in Lithuania has a suitable chemical composition for application in the nutrition of monogastric animals. In the compound feed of broiler chickens, up to 15% of wheat could be replaced by triticale without affecting performance and digestive processes of broilers.

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