Journal of Animal and Veterinary Advances 8 (7): 1316-1321, 2009
ISSN: 1680-5593

Effect of Triticale Replacement and Enzyme Supplementation on Performance and Blood Chemistry of Broiler Chickens

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Abstract: A factorial design experiment was conducted to study the performance of broiler chickens fed five different levels of triticale replaced for corn (0, 25, 50, 75 and 100%), in a corn-soy based diet with/without exogenous enzyme supplementation. Each treatment diet fed to four groups of ten male birds each. The starter, grower and/or finisher diets were isocalric and isonitrogenous and fed *ad libitum* from 4-10, 11-28 and 29-42 days of age, respectively. Similar weight gain, feed intake and feed conversion observed in birds fed control or diets contained up to 75% triticale replaced for corn. However, the average daily feed intake and feed conversion were increased when 100% of corn was replaced with triticale during 4-42 days of age ($p<0.01$). The exogenous enzyme supplementation did not affect broiler performance. Gizzard and small intestine weights increased with an increase in triticale in diet when measured at 18 and 42 days of age. This study revealed that diets containing up to 40% triticale (or 75% of corn replacement) had no negative effect on broiler performance. Whereas chickens blood serum cholesterol and HDL were elevated when fed enzyme supplemented corn or triticale-soy diets.

Key words: Broilers, triticale, enzyme supplementation, performance, blood chemistry, corn

INTRODUCTION

Triticale, a hybrid of wheat and rye is an alternative cereal grain to maintain metabolizable energy of broiler chicken diets. Triticale has an excellent productivity potential and a greater flexibility to adapt to difficult agronomic conditions than wheat (Korver *et al*., 2004). Plant breeders have continued to improve triticale nutritional values for poultry diets. The genetic improvements in triticale have increased grain plumpness and lowered the protein content. Boros (1999) proposed that the negative effects observed in early triticale varieties are less prominent in newer varieties that have a smaller proportion of the rye genome compared with the wheat genome.

Some studies have shown that the negative effects of triticale do not appear when the proportion of this grain is limited to as little as 15% of total grain in chicken diet. However, other studies reported no deteriorating effect on productivity of broilers and/or layers when diets grain portion consisted of 100% triticale (Boros, 1999; Chapman *et al*., 2005).

The use of triticale in broiler feed is limited by the presence of soluble non-starch polysaccharides, particularly xylans and arabinoxylans components (Pourreza *et al*., 2007). These compounds reduce the nutritive value of triticale by increasing gut viscosity and thus reducing the availability of nutrients for digestion and absorption (Choct and Annison, 1992). Pettersson and Aman (1988) reported significant improvement in growth and feed conversion of broilers when triticale diets were supplemented with an enzyme cocktail containing a high level of β-glucanase and pentosanase activity.

Information about the use of triticale in poultry diets and the effect of supplemental enzymes on its nutritional value is limited as compared to other cereal grains. The present experiment was conducted to study the performance and blood chemical characteristics of broiler chickens fed diet containing different levels of triticale supplemented with/without exogenous enzyme.

MATERIALS AND METHODS

Birds, housing and care: Four hundred days old male broiler chicks of commercial strain (Ross 308) were obtained from a commercial hatchery and kept in an senvironmentally controlled floor house until 3 days of

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age. Chicks were individually weighed and were randomly assigned to 10 dietary treatments with 4 replicate pens of 10 chicks each on day 4's. Each pen was one square meter and covered with wood shaving. The house temperature was initially maintained at 32°C and reduced 2.5°C every week to reach a constant temperature of 20-22°C at 28 days of age. A continuous lighting was used for the first 3 days and a 23:1 h light:dark cycle was applied for the rest of the experimental period. Birds were allowed free access to the feed from trough feeder (7 cm length bird^{-1}) and fresh water from nipple drinkers (2 nipples pen^{-1}) throughout the experiment.

Experimental design and diets: The experiment was a completely randomized design with a factorial arrangement of five triticale levels (0, 25, 50, 75 and 100% replaced for corn) by 2 levels of enzyme supplementation. The enzyme levels were 0 and 500 ppm of an enzyme cocktail (containing xylanase min 1200 unit g^{-1} and β-glucanase 440 unit g^{-1}) in diet. Diets were formulated according to the recommended nutrients by the Ross 308 manual for broiler chicks and were offered in mash form. The composition of the experimental diets is shown in Table 1. The starter, grower and/or finisher diets were provided isocalric and similar nutrients and fed *ad libitum* from 4-10, 11-28 and 29-42 days of age, respectively.

Measurements: Live body weight and feed weighed in and weighed back per pen were measured at day 4, 10, 28 and 42 days of age. Weight gain, feed intake and feed conversion for starter, grower, finisher and overall periods were calculated. Daily chick mortality were weighed, recorded and added to the total pen live body weight for the calculation of feed conversion during each respective period. One bird close to the average pen weight of chicks was selected and after 8 h of starvation weighed, slaughtered and edible carcass parts and digestive tracts (gizzard, small intestine and large intestine) were dissected and weighed at 18, 28 and 42 day of age. Carcass was obtained by removing head, legs below the tibia-tarsal joint, feathers and gastro-intestinal tract from the slaughtered birds. The lengths of the intestinal segments were measured after being flushed with water. The weight of heart, liver and pancreas were also recorded. One bird from each replicate was randomly selected and after 8 h of starvation 3 mL of blood from wing vein was withdrawn into a syringe at 42 day of age. The blood serum samples were used to determine Fast Blood Sugar (FBS),

Table 1: Composition of the experimental diets

	Percentage of triticale replacement for corn[1]														
	4-10 days					11-28 days					29-42 days				
Ingredients (%)	0	25	50	75	100	0	25	50	75	100	0	25	50	75	100
Corn	51.2	39.0	26.1	13.2	-	49.7	37.8	25.4	13.0	-	57.3	43.7	29.3	14.9	-
Triticale (11% cp)	-	12.8	26.1	39.6	53.3	-	12.4	25.4	38.3	52.1	-	14.2	29.3	44.2	59.8
Soybean meal (44% CP)	41.6	40.7	39.8	39.0	38.2	40.8	40.0	39.1	38.3	37.3	33.5	32.6	31.6	30.7	29.6
Soybean oil	2.93	3.21	3.61	3.79	4.2	5.60	5.90	6.10	6.40	6.75	5.45	5.80	6.10	6.48	6.85
Limestone	1.17	1.17	1.15	1.15	1.15	1.10	1.10	1.10	1.10	1.10	1.07	1.07	1.07	1.07	1.07
Di Ca-phosphate	1.75	1.75	1.75	1.75	1.70	1.65	1.65	1.65	1.64	1.65	1.55	1.55	1.55	1.55	1.55
Sodium chloride	0.45	0.47	0.50	0.52	0.55	0.45	0.47	0.50	0.52	0.55	0.37	0.40	0.42	0.45	0.49
Vit-min permix[2]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Hcl-lysine	0.20	0.20	0.21	0.21	0.21	-	-	-	-	-	-	-	-	-	-
DL-Methionine	0.20	0.19	0.18	0.17	0.16	0.22	0.21	0.2	0.19	0.18	0.18	0.17	0.16	0.14	0.13
Calculated nutrients															
ME (kcal kg^{-1})	2990	2990	2990	2990	2990	3150	3150	3150	3150	3150	3220	3220	3220	3220	3220
CP (%)	22.6	22.6	22.6	22.6	22.6	22.2	22.2	22.2	22.2	22.2	19.6	19.6	19.6	19.6	19.6
Ca (%)	1.00	1.00	1.00	1.00	1.00	0.95	0.95	0.95	0.95	0.95	0.90	0.90	0.90	0.90	0.90
Av. P (%)	0.50	0.50	0.50	0.50	0.50	0.48	0.48	0.48	0.48	0.48	0.45	0.45	0.45	0.45	0.45
Na (%)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.20	0.20	0.20	0.20	0.20
Lys (%)	1.40	1.40	1.40	1.40	1.40	1.23	1.22	1.22	1.22	1.21	1.05	1.05	1.04	1.04	1.04
Met (%)	0.55	0.54	0.54	0.54	0.53	0.56	0.56	0.55	0.55	0.54	0.49	0.49	0.48	0.48	0.47
Met + Cys (%)	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.81	0.81	0.81	0.81	0.81
Analyzed															
Dry matter (%)	89.5	90.5	89.0	90.0	90.5	89.5	89.4	89.0	90.5	90.9	90.5	90.9	89.5	89.4	90.0
Crude protein (%)	23.8	23.7	23.8	24.0	24.0	23.8	23.5	23.8	23.5	23.9	21.8	21.5	21.8	21.5	21.9
Crude fiber (%)	4.6	4.7	4.8	4.5	4.5	4.6	4.7	4.8	4.5	4.5	4.6	4.7	4.8	4.5	4.5
Calcium (%)	1.15	1.15	1.10	1.10	1.10	1.04	1.01	1.10	1.10	1.10	1.04	1.01	1.10	1.10	1.10
Phosphorous (%)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

[1]Diets with or without the enzyme complex; 0 or 500 ppm of an enzyme cocktail containing xylanase min 1200 unit g^{-1} and β-glucanase 440 units g^{-1}; [2]Supplied/kg of diet: vitamin A, 10000 IU; vitamin D3, 9790 IU; vitamin E, 121 IU; vitamin K2, 2 mg; vitamin B12, 0.02 mg; thiamine, 4 mg; riboflavin, 0.0044 mg; niacin, 22 mg; pyridoxine, 4 mg; biotin, 0.03 mg; folic acid, 1 mg; Ca-panthotenate, 40 mg; choline chloride, 840 mg; etoxycoin, 0.125 mg; Zn-sulfate, 60 mg; Mn-sulfate, 100 mg; Cu-sulfate, 100 mg; Se, 0.2 mg; I, 1 mg; Fe, 50 mg

Triglyceride (TG), cholesterol, High-Density Lipoproteins (HDL) and Low-Density Lipoproteins (LDL). Diet samples were analyzed for Dry Mater (DM) at 100°C for 24 h, Crude Protein (CP) by the Kjeldahl method, Crude Fiber (CF), calcium by the dry ash method and phosphorus by the photometric method.

Statistical analysis: All percentage data were transformed to arc-sin before statistical analysis. All data were analyzed by ANOVA using the GLM procedure of the SAS software (SAS Institute, 2004) according to the following general model. Means were compared for significant differences using Duncan's Multiple Range Test ($p<0.05$).

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

where:

Y_{ijk}	=	The observed dependent variable
μ	=	The overall mean
α_i	=	The effect of level of triticale replacement for corn
β_j	=	The effect of enzyme supplementation
$(\alpha\beta)_{ij}$	=	The interaction between triticale replacement for corn and enzyme supplementation
ε_{ijk}	=	The random error

RESULTS AND DISCUSSION

The average body weight of 3 days old chicks was about 70 g and chicks pen weight, were similar before they were allocated to the dietary treatment on day 4 of age. The average weight gain, feed intake and feed conversion of chicks fed diets with different levels of triticale replacement for corn and supplied with/without enzymes are shown in Table 2. Weight gain of birds was not influenced by triticale or enzyme supplementation, during any or whole period of experiment. Whereas feed intake and feed conversion ratio was significantly ($p<0.05$) increased in birds fed triticale-soy diet as compared to those fed corn-soy or corn-triticale-soy diet during each and/or whole period, with an exception of 4-10 days for feed intake and 4-10 and 29-42 days for FCR. The triticale replacement for 75% of corn (or 40% of diet) did not affect weight gain, feed intake and/or FCR. Similarly, Vieira *et al.* (1995) reported that the inclusion level of triticale up to 40% in corn-soy diet did not have any negative effect on weight gain or final weight of broiler chickens. Other studies showed that production of birds, even when fed diets contained of 100% triticale of the grain portion was similar to those fed control diet (Chapman *et al*., 2005). Although, the feed conversion rate and feed intake of birds fed diets with 40% or more triticale (over 75% replacement for corn) was higher than those fed corn-soy diet, poorer FCR was observed in birds fed triticale-based as compared to those fed corn-based diet (Hermes and Johnson, 2004; Vieira *et al*., 1995). Korver *et al*. (2004) reported a 4-5% reduction in average FCR of broiler chickens fed triticale-based compared to corn based diet during 0-2 or 2-3 weeks. The poor FCR of birds fed triticale based diet may be related to lower nutrients, lower nutrient digestibility or higher anti-nutrient factors in triticale as compared to corn. The anti-nutritional factors in triticale includes: soluble pentosans, trypsin inhibitor, alkyl-resorcinols and pectins (Pettersson and Aman, 1988; Korver *et al*., 2004). Weight gain, feed intake and/or FCR was not significantly ($p>0.05$) influenced by exogenous enzyme supplementation (Table 2). The addition of enzyme in other experiments significantly improved the performance of broiler chickens fed triticale-soy diet as compared to corn-soy diet (Al-Athari and Guenter, 1988; Pettersson and Aman, 1988; Pourreza *et al*., 2007). The different results obtained in our experiment and other reports may be due to the type of enzyme cocktail and/or variety of triticale used in this experiment as compared to other experiments. Specially, the new varieties of triticale may contain less anti-nutrients such as pentosans and other non-starch polysaccharides. Pettersson and Aman (1988) added enzyme cocktail with high level of β-glucanase and pentosanase activity to the triticale diets and observed an improvement in growth and FCR of birds as compared to those fed diet without enzyme supplementation.

There were not significant ($p>0.05$) differences in carcass yield and/or cuts of birds fed diets with different levels of triticale replacement for corn and supplied with/without exogenous enzymes when slaughtered at 42 days of age. The gizzard weight at 28 days and small intestine weight as percentage of LBW at 42 days of age was significantly increased ($p<0.05$) as triticale was replaced for corn. Whereas, large intestine weight was not affected by triticale replacement in diet when measured at 18, 28 and/or 42 days of age. Enzyme supplementation did not have any effect ($p>0.05$) on gizzard, small intestine and/or large intestine weight measured at different ages. The significant increase in empty intestine or gizzard weight in birds had higher triticale in their diet may be due to enhanced function of these part of gut with subsequent increase in feed intake (Table 2). The higher non starch polysaccharides in triticale as compared to corn can increase digesta viscosity and reduce enzyme-nutrient and their subsequent substrates, leading to significant modifications of the structure and function of intestine (Wang *et al*., 2005) and to adapt to these changes, the activities of the intestinal secretary

Table 2: Effects of dietary triticale level and enzyme supplementation on performance, weight gain, feed intake and feed conversion of broiler chicks fed corn- soybean meal diet

	Weight gain (g/b/days)				Feed intake (g/b/days)				Feed conversion (g:g) (days)			
Main effects	4-10	11-28	29-42	4-42	4-10	11-28	29-42	4-42	4-10	11-28	29-42	4-42
Triticale replacement (corn (%))												
0	19.1	49.1	86.1	57.0	33.3	85.8[b]	191[b]	115[b]	1.75	1.65[b]	2.26	1.99[b]
25	18.1	46.4	82.5	54.0	32.7	92.8[ab]	192[b]	118[b]	1.83	1.87[ab]	2.37	2.10[ab]
50	18.9	48.7	81.2	55.0	32.8	87.7[ab]	188[b]	114[b]	1.73	1.69b	2.41	2.10[ab]
75	18.3	46.9	78.3	53.0	34.7	90.5[ab]	195[b]	118[b]	1.91	1.83[an]	2.46	2.20[ab]
100	17.9	47.2	87.5	56.0	34.1	97.0[a]	215[a]	128[a]	1.91	1.99[a]	2.61	2.29[a]
Enzyme supplementation (ppm)												
0	18.4	47.6	83.3	55.0	33.40	91.2	199	120	1.80	1.80	2.50	2.10
500	18.5	47.7	82.9	55.0	33.70	90.4	193	118	1.80	1.80	2.30	2.10
SEM	1.4	12.8	143.0	26.0	6.28	37.7	340	67	0.04	0.03	0.15	0.04
Source of variation	Probability											
Triticale replacement	0.25	0.45	0.55	0.54	0.46	0.01	0.05	0.01	0.27	0.01	0.51	0.03
Enzyme supplementation	0.82	0.93	0.90	0.94	0.68	0.67	0.30	0.35	0.90	0.94	0.12	0.21
Triticale x Enzyme	0.15	0.06	0.65	0.42	0.10	0.28	0.40	0.42	0.48	0.16	0.79	0.71

Mean with no common superscript differ significantly ($p<0.05$)

mechanisms may be enhanced. Thus, this may lead to an increase in the size of the Gastro Intestinal Tract (GIT), pancreas and liver. Brenes *et al*. (1993) indicated that this increased size of intestine and GIT could be an adaptive response to an increased need for enzymes. When supplementing exogenous enzymes in the wheat control diet, a greater proportion of NSP may be hydrolyzed, which might attenuate the secretary function of the responding organs and GIT segments and then the organ sizes may decrease. Brenes *et al*. (1993) also implied that the reduction in relative organ weight had a direct economic benefit, as the dressing yield of broilers should increase proportionally. Effects of enzyme supplementation on empty segment of gut weights are shown in Table 3. Increasing enzyme supplementation increased the relative size of large intestine of broiler measured at day 42 ($p<0.05$). In general, the inclusion of exogenous enzymes significantly altered the morphology of the different GIT segments compared with control diet. Brenes *et al*. (1993) have reported that enzyme treatment of barley-based diets can reduce the relative length of duodenum, jejunum and ileum, but enzyme inclusion did not have a significant effect on organ size of birds fed a wheat-based diet.

There were not significant differences in total serum Fast Blood Sugar (FBS), Triglyceride (TG) and Low-Density Lipoproteins (LDL) between birds fed diet with different level of triticale measured at 42 days of age. The chickens fed diet supplemented with 500 ppm of enzyme cocktail contained min of 1200 unit g^{-1} xylanase and 440 units g^{-1} β-glucanase, had higher ($p<0.05$) cholesterol concentration than birds fed diet without enzyme addition (143 vs. 134 mg mL^{-1}). The replacement of triticale for corn in diet did not have a significant effect on serum cholesterol concentration but with increasing levels of triticale replacement from 0-100% for corn the average serum cholesterol concentration numerically decreased. The chickens blood serum HDL was significantly influenced by enzyme supplementation ($p<0.002$) and the interaction between triticale replacement for corn in diet and enzyme supplementation was significant ($p<0.02$). The birds fed diet supplemented with enzyme had higher HDL concentration than these fed diet without enzyme supplementation (90 vs. 83 mg mL^{-1}). The average serum concentration of HDL was numerically reduced when triticale replaced for corn in diet (Table 4). Inclusion of highly viscous grain in diet induced bird plasma cholesterol levels as compared with control group. Soluble dietary fibers, such as mixed linked β-Glucans, may reduce the absorption of fat and cholesterol and are known to have cholesterol lowering properties. These effects are all associated with the viscosity-forming properties of soluble dietary fibers (Pettersson and Aman, 1993). Aline *et al*. (2001) reported that plasma cholesterol was lower than control rats fed whole wheat and triticale flour diets. Several mechanisms that might explain the hypocholesterolemic effect of dietary fiber, whether working alone or in combination, have been proposed as slowing down the rate of gastric emptying, modification of bile acid absorption and metabolism, interference with lipid absorption and metabolism, production of Short-Chain Fatty Acids (SCFA) from fermentation of fiber in the colon, up regulation of the hepatic LDL receptor and alterations in plasma concentration or tissue sensitivity to insulin or other hormones (Anderson *et al*., 1990; Jackson *et al*., 1994).

Table 3: Effect of dietary triticale level and enzyme supplementation on digestive organ weight of broiler chicks fed corn- soybean meal diet

	Gizzard (%) LBW (days)			Small intestine (%) LBW (days)			Large intestine (%) LBW (days)		
Main effects	18	28	42	18	28	42	18	28	42
Triticale replacement (corn (%))									
0	2.9	2.3^{b}	1.6	4.1	3.6	2.7^{b}	0.68	0.63	0.43
25	2.8	2.2^{b}	1.7	4.2	4.16	2.6^{b}	0.59	0.65	0.43
50	2.9	2.2^{b}	1.5	4.4	3.8	2.8^{ab}	0.57	0.62	0.48
75	2.9	2.7^{a}	1.8	4.5	4.17	2.9^{ab}	0.67	0.61	0.44
100	3.1	2.9^{a}	1.8	4.6	4.4	3.5^{a}	0.62	0.60	0.46
Enzyme supplementation (ppm)									
0	2.9	2.46	1.7	4.2	3.9	2.8	0.59	0.61	0.41
500	3.0	2.48	1.7	4.6	3.16	3.0	0.66	0.64	0.48
SEM	0.44	0.67	0.7	1.28	0.95	0.81	0.27	0.22	0.14
Source of variation	Probability								
Triticale replacement	0.64	0.01	0.37	0.75	0.2	0.05	0.42	0.97	0.71
Enzyme supplementation	0.52	0.86	0.88	0.13	0.28	0.25	0.12	0.54	0.03
Triticale x Enzyme	0.27	0.88	0.26	0.81	0.24	0.03	0.4	0.33	0.83

Mean with no common superscript differ significantly ($p<0.05$)

Table 4: Effect of dietary triticale level and enzyme supplementation on Fast Blood Sugar (FBS), Triglyceride (TG), Cholesterol (Ch), High-Density Lipoproteins (HDL) and Low-Density Lipoproteins (LDL) of broiler chicks fed corn-soybean meal diet measured at 42 days of age

Main effects	FBS	Ch	TG	HDL	LDL
Triticale replacement (corn (%))					
0	193	144	56	91	42
25	201	138	55	85	44
50	196	139	60	86	41
75	187	137	54	87	40
100	198	134	49	82	39
Enzyme supplementation (ppm)					
0	200	134	52	83	42
500	189	143	57	90	40
SEM	687	209	461	51	63
Source of variation	Probability				
Triticale replacement	0.86	0.68	0.87	0.170	0.74
Enzyme supplementation	0.19	0.04	0.43	0.002	0.33
Triticale x Enzyme	0.87	0.14	0.57	0.020	0.18

Mean with no common superscript differ significantly ($p<0.05$)

CONCLUSION

- Triticale may be used as an alternative source of energy in broiler diets
- The inclusion of up to 40% triticale in broiler diet does not have any negative effect on performance of broiler chickens
- Triticale seems to have a lowering properties for serum cholesterol, triglycerides and HDL in chickens

ACKNOWLEDGEMENTS

We greatly acknowledge financial support of this research from the Ferdowsi University of Mashhad and Agricultural Teaching Excellence Center of Khorasan Razave province, Iran.

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