IJAS Iranian Journal of Applied Animal Science

Performance Characteristics and Nutritional Comparison of Broiler Chickens Fed with Barley and Triticale Based Diets

Research Article

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Received on: 6 Jun 2014
Revised on: 18 Aug 2014
Accepted on: 31 Aug 2014
Online Published on: Jun 2015

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Online version is available on: www.ijas.ir

ABSTRACT

This study was performed with growing chicken (14 to 56 d of age) to evaluate the effects of feeding them a barley or triticale-based diet. The treatments were corn diet (1) as a control, hulless barley diet with (5) or without (2) enzyme, triticale diet with (6) or without (3) enzyme and hulled barley diet with (7) or without (4) a commercial β-glucanase enzyme. In a digestibility trial, 21 male broiler chicks were used at 45 days old. Each of the seven treatments was replicated three times. No significant difference (P>0.05) was observed between (2) to (7) treatments with corn diet for weight gain and feed intake during growing period, but hulled barley with no treatment (4) had less weight gain and higher feed conversion (lower efficiency) than other cereals. Ether extract digestibility increased significantly in all the enzyme treated diets compared to corn diet (P<0.05). Metabolizable energy corrected for nitrogen (AMEn) was less in hulled barley with no treatment, compared to corn and triticale treated with enzyme (P<0.05). Reduction of serum cholesterol was observed in birds on hulless barley diet (P<0.05), but serum creatinin did no show any significant difference between treatments (P>0.05). Higher serum immunoglobulin (IgG) was detected in broiler fed the hulled barley diet with no treatment, than the enzyme-treated barley and corn diets (P<0.05). Mean percentage of liver showed the highest percentage in hulled barley diet with no treatment (P<0.05) and fresh carcass was the lowest in chickens on triticale with no treatment (P<0.05). It was concluded that the enzyme supplementation is beneficial in terms of weight gain, feed intake, and feed conversion during 14-42 days old in chickens, but these positive effects of enzyme will be fade in aged chicken due to the higher capacity of alimentary tract for digestion of feed materials.

KEY WORDS barley, broiler, digestibility, enzyme, growth performance, hulless barley, triticale.

INTRODUCTION

Cereal grains are the major source of energy for commercial poultry and represent about 60-70% of the diets. Maize and wheat are mainly used in production of feed mixtures for broilers, but their content in diets might be reduced for economic reasons (Józefiak *et al*. 2007; Zarghi and Golian, 2009). Triticale is an alternative cereal grain that is a hybrid between rye and wheat (Boros, 1999). Triticale is a grain that competes with other species in terms of lower soil requirements, high yielding potential and nutritive value, which are comparable to wheat and rye (Leeson and Summers, 2001). Hulless barley has a higher AME and protein content than hulled barley because of the diluting effect of the fibrous hull (Classen *et al*. 2000). Based on chemical analysis, Moharrery (2006) determined that hulless barley had higher crude protein (CP) than hulled barley. Removal of the hull from barley increases its digestible energy con-

tent, but also increases the proportion of starch. However, similar to wheat and rye, all the grains mentioned above contain β-glucan and the possible adverse effects of β-glucan on animal performance (Mathlouthi *et al.* 2002; Moharrery, 2006) make them a cereal of increasing interest to study. Exogenous enzymes have been used extensively to remove anti-nutritional factors from feeds, to increase the digestibility of existing nutrients, and to supplement the activity of the endogenous enzymes of poultry (Classen *et al.* 1991; Bedford, 1993). Currently, most of the enzymes that are used in feeds are xylanases for wheat and rye-based diets and β-glucanases for barley and oat-based diets. The objective of this study was to investigate the effect of corn replacement by triticale, hulless and regular barley (hulled) with or without enzyme supplementation. This was done by recording production performance of broilers, evaluation of blood metabolites, immunological responses, and carcass characteristics of broilers.

MATERIALS AND METHODS

Animals and diets

Two hundred and eighty 1-d-old commercial broiler chickens (Ross-308) from both sexes were housed in floor pens containing litter with wood shavings and they received a corn-based starter diet (Table 1). At 14 days of age, all the chickens were divided into 28 groups, 10 chickens per group. Each one of the 7 experimental diets was fed to 4 groups of chickens for 56 days. Dietary treatments as grower and finisher diets (Table 1), consisted of:

1. A corn-based diet as a control.
2. A hulless barley-based diet, without enzyme supplementation or with enzyme supplementation (5).
3. A triticale-based diet, without enzyme supplementation or with enzyme supplementation (6).
4. A hulled barley-based diet, without enzyme supplementation or with enzyme supplementation (7).

The exogenous enzyme used in this treatment was the commercial powdered preparation Endofeed, Reg No. 280003 (GNC Bioferm INC. Saskatchewan, Canada S7H 3A6) with β-glucanase activities. The enzyme preparation was added to the diets at the level of 0.5 g/kg of diet for treatments 5, 6 and 7. Feed and water were supplied *ad libitum* throughout the entire experiment. Body weights were determined at 14, 42 and 56 d of age and feed intake over these periods was recorded. Feed conversion (g feed per g body mass-FC) was calculated after dividing the cumulative feed consumption for each pen by the total bird mass of that pen. All mortalities were weighed, recorded and their weights were included in the calculation of feed conversion.

Digestion trial

A digestion trial was performed using 21 male broiler chicks from 45 to 52 d of age. This period of age consisted of 4 days of adaptation, followed by 72 h with access to 85 g feed from each treatment. Twenty one birds (3 replicate for each diet) were housed in individual layer cages with wire bottoms. Birds had free access to water throughout the experiment. The cages were kept in a room at 22 ˚C and approximately 58% ± 3 relative humidity. Excreta were collected for each 24-hour period of days 50, 51 and 52. Contamination, such as down and scales, was carefully removed, and the excreta stored in containers at -25 ˚C. Excreta samples were subsequently dried in the oven at 70 ˚C, weighed, ground through a 0.5 mm sieve and stored an air-tight plastic vessel at 4 ˚C until analysis.

Carcass characteristics and blood samples collection

At the end of the experiment (56 d of age), two birds of each pen (one male and one female) were bled by cutting the carotid artery and blood was taken from this artery. The blood samples were centrifuged for 15 min at 2000×g, and the serum was harvested and stored at -80 ˚C. The carcass feather removal was accomplished in a free-action picker after subscalding at approximately 60 ˚C. Heads and shanks were removed and the remaining carcasses were dissected to breast, thigh, wings, neck, liver, and weighed. The percentage yield of each part was calculated on the basis of carcass weight.

Chemical measurements

Total fat contents of feed and excreta were determined by extraction of samples with petroleum ether. The determination of nitrogen in the feed and excreta was performed by the macro-Kjeldahl method. Because a part of nitrogen in excreta originates from uric acid, the faecal nitrogen should be corrected for uric acid nitrogen (Rotter *et al.* 1989). In this regard, the excreta were calculated as total nitrogen minus nitrogen in uric acid. The apparent metabolizable energy of each diet was calculated from the gross energy values of the diet and dried excreta. Gross energy values were measured using a bomb calorimeter (Shimadzu Automatic Bomb Calorimeter CA-3). Serum samples were also analysed for triacylglycerols using an enzymatic and colorimetric procedure (Kit 10-525, Ziestchem Diagnostic Kit, Tehran, Iran), for cholesterol by an enzymatic procedure (Kit 10-508, Ziestchem Diagnostic Kit, Tehran, Iran) and for glucose by a colorimetric procedure (Kit 10-518, Ziestchem Diagnostic Kit, Tehran, Iran). The concentration of serum IgG was evaluated using a commercial ELISA kit (Bethyl, Co., 25043 West FM 1097, Montgomery, TX 77356, USA, Catalog No. E30-104).

Table 1 Composition of experimental diets

Ingredients and analysis	Starter	Experiment diet			
		14 to 42-d		42 to 56-d	
		Corn-based	Cereal-based[1]	Corn-based	Cereal-based[1]
		g/kg			
Ground yellow corn	618	485	150	615	300
Ground grain[1]	-	-	350	-	350
Soybean meal (44% CP)	280	330	310	190	180
Fish meal	49.5	27	30	20	18
Plant oil	19	19	50	25	50
Wheat bran		84	55	95	50
Dicalcium phosphate	12	28	28	28	28
Oyster shell	13	10	10	10	10
Sodium chloride	1	4.5	1.5	4.5	1.5
DL-methionine	0.5	2.5	2.5	2.5	2.5
Vitamin/mineral premix[2]	7	10	10	10	10
Analyses (calculated)[3]					
AME (kcal/kg)	3000	2720	2719	2891	2891
Crude protein (%)	20.78	21.89	21.85	16.62	16.64
Methionine (%)	0.44	0.61	0.59	0.53	0.51
Methionine + Cysteine (%)	0.75	0.94	0.92	0.79	0.77
Lysine (%)	1.21	1.26	1.26	0.86	0.86

[1] In diets (2) to (7), the same level of barley or triticale was used.
[2] The premix supplied the following (mg/kg diet): Retinol 3.6 (about 1.1 IU.KJ^{-1}); Cholecalciferol: 0.075 (about .26 IU.KJ^{-1}); Biotin: 1 g; DL-α-tocopherylacetate: 10 g; Riboflavin: 10 g; Pantothenate: 20 g; Choline: 2000 g; Niacin: 100 g; Thiamine: 10 g; Pyridoxine: 10 g; Menadin sodium bisulphate: 1.5 g; Cyanocobalamin: 0.1 g; Folic acid: 2 g; Ethoxyquin: 150 g; Mn: 100 g; Fe: 100 g; Cu: 10 g; Co: 1 g; I: 1 g and Zn: 100 g.
[3] Estimated from (NRC, 1994) composition tables.

The operating procedure was carried out according to the manufacturers' instructions.

Statistical analysis

The complete randomised model was used to analyse performance and digestibility data. In this regard, seven treatments were offered to the chickens in four replicates individually. The experimental design for carcasses was a completely randomized one with a 7 × 2 factorial arrangement of treatments. Each of the seven treatments was replicated four times per sex (n=4). The data were analysed using the general linear model procedure of SAS (2003). Duncan's multiple range test ($P<0.05$) was used to test the significance of difference between means. The percentage values were transformed to arcsine and analysed, but the values that are reported were converted to the initial form. Values are given as means, and the homogeneity of variance was checked.

RESULTS AND DISCUSSION

Growth performance

Growth performance, feed intake and feed conversion are shown in Table 2. No differences ($P>0.05$) in feed intake were observed through day 42. Weight gain was significantly reduced ($P<0.05$) by the use of treatment (4) at 42 and 56 d. The barley diet, which was treated with a commercial enzyme (7) showed the same result as the corn based diet and superior performance to the barley without any treatment (4), indicating that the efficiency of dietary utilisation was increased in chicks fed the enzyme (7). The lowest weight gain occurred in broilers fed (4), compared with other treatments during days 14 to 42, suggesting that the hull fibre may be the cause. The combination of β-glucan along with insoluble fiber (hull) may act in synergy to produce negative effects.

Enzyme supplementation in the triticale-based diet improved ($P<0.05$) the broiler chicken performance at 42 and the feed conversion at 42 and 56 d ($P<0.05$). Triticale contains pentosans which impair the performance of chicks due to increasing gut viscosity and reducing nutrient digestibility at high levels of inclusion. Response to enzymes probably is due to hydrolysis of β-glucan and consequently the elimination of the negative effects of this polysaccharide on chicks.

A negative effect of hulled barley inclusion to the diets (treatment no. 4) was shown in this study for weight gain and feed conversion ($P<0.05$). The reason for this aspect is due to the physical structure of the barley kernel, with its sharp spikets, birds are often reluctant to consume the hulled grain. Another problem encountered with barley, is the β-glucan content and its associated problem of the formation of viscous digesta. This problem was overcome with the use of enzyme in treatment no. 7. Overall, negative effects of replacing corn with other grains in the diets were not shown in this study. The reason for this aspect is partly related to including these grains to the diet after 2 weeks of age.

Table 2 Growth performance of broilers fed different cereal-based diets from 14 to 42 or 56 days of age

Days 14 to 42	Treatment[1]							SEM	P*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Weight gain, g	1413^{bcd}	1468^{abc}	1373^{cd}	1314^{d}	1511^{ab}	1549^{a}	1396^{cd}	34.54	0.0013
Feed intake, g	2909	2856	2886	2968	2898	2909	2870	35.74	0.4374
Feed conversion	2.06^{bc}	1.95^{bc}	2.11^{ab}	2.27^{a}	1.92^{bc}	1.88^{c}	2.06^{bc}	0.068	0.0080
Days 14 to 56									
Weight gain, g	2222^{b}	2348^{a}	2323^{a}	2136^{b}	2348^{a}	2389^{a}	2189^{b}	29.51	< 0.0001
Feed intake, g	5061^{ab}	5190^{ab}	5306^{a}	5160^{ab}	5047^{ab}	5045^{ab}	5005^{b}	81.54	0.1654
Feed conversion	2.28^{b}	2.21^{bc}	2.28^{ab}	2.42^{a}	2.15^{bc}	2.11^{c}	2.29^{ab}	0.04	0.0020

[1] (1): corn; (2): hulless barley; (3): triticale; (4): hulled barley; (5): hulless barley + enzyme; (6): triticale + enzyme and (7): hulled barley + enzyme.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
* Probability.

During the first 2 weeks of age, the gastrointestinal tract, especially the small intestine epithelium, is not completely mature (cellularity and enzymology) so that the chicks could not overcome the effect of any material such as non starch polysaccharides (NSP) in their diets (Henning, 1979; McNab and Smithard, 1992). Improvements in the performance of poultry fed on diets containing barley to which enzymes had been added were first reported more than 45 years ago (Jensen *et al*. 1957). In the present study it was shown that adding enzyme to the diet (treatment no 5, 6 and 7) increased the weight attained by broilers at 42 and 56 days of age by just over 7.2 and 1.7%, respectively (P<0.05). Corresponding improvements in feed conversion efficiency were showed in this treatment. Among the several hypotheses relating to the mechanism of enzyme action, the decrease of digesta viscosity by NSP degrading enzymes is more highly validated. Based on this hypothesis, enzymes can hydrolyse the glycoside bonds of large molecules that are responsible for increasing the digesta viscosity. This action alleviates the anti-nutritional effect of soluble NSP (Bedford and Classen, 1993). In addition to the effect of NSP on increasing viscosity, other physicochemical properties of NSP such as the stirred water layer of the gut, bonding capacity, etc., are involved in digestibility and nutrient absorption (Smits and Annison, 1996).

At present there are two major types of hulless barley, normal and waxy. The normal type has the traditional ratio of amylose to amylopectin starch fractions as found in regular barley (hulled). The waxy type has a very high percentage of amylopectin starch. Markets for waxy barley are being developed. The hulless-barley in treatment (2) has shown the same results compared with the same barley treated by a commercial enzyme for weight gain, feed intake and feed conversion. The result of this study suggested that the β-glucan is not a uniqe factore for the negative effects of barley. The combination of β-glucan and insoluble fiber (hull) may in synergy for producing negative effects. Newman *et al*. (1985) reported that the alkaline viscosity of unpearled barley was 2.27 cp and of the pearled, 1.99 cp. By removing one of the factors such as β-glucan [adding enzyme (5) or (7)] or insoluble fiber (hulless barley) better performance will be expected. This result is in contrast to Scott *et al*. (1998) who reported that the hulless barley cultivars significantly reduced the excreta dry matter (DM), feed intake, 17-d body weight (BW) and increased feed to gain ratio. They mentioned that the enzyme has a greater effect on the hulless variety. In agreement with the results of the present study Classen *et al*. (2000) reported that hulless barley has a higher apparent metabolizable energy (AME) and protein content than hulled barley because of the diluting effect of the fibrous hull. They also mentioned that within hulless barley cultivars, low fiber content has been suggested to further enhance the nutritional value for broiler chickens.

Feed digestibility and metabolizable energy

Apparent digestibilities of dry matter, crude protein and ether extract of all of the experimental diets from 45-52 days of age are shown in Table 3. Despite the fat and protein, other nutrient digestibilities showed no significant difference among experimental diets (P>0.05), and fat and protein digestibilities in the corn-based diet (1) shows significantly lower value compared with other treatments (P<0.05). Various authors have suggested that the low lipid digestibility in broiler chickens may be due to bacterial overgrowth in the small intestine and subsequent excessive deconjugation of bile acids, which reduces their efficacy in solubilizing lipids (Huhtanen and Pensack, 1965; Salih *et al*. 1991). The adjusted crude protein digestibility showed no significant difference among experimental diets (P>0.05). Volatile fatty acids and polyamines produced by gut bacteria have stimulatory effects on the proliferation rate and secretory activity of the intestinal mucosa (Furuse *et al*. 1991; Osborne and Seidel, 1989).

Before correcting for the concentration of uric acid in the excreta of experimental diets, a significant difference was observed between corn-based diet (1) and hulless barley-based diet (2), but after correction for the uric acid concentration no significant difference was observed (P>0.05). The reason for this result was partly explained by excretion

of nitrogen through uric acid. In this regard, a high amount of uric acid from the corn-based diet could be related to lower availability and digestibility of protein and, therefore, eliminated nitrogen excretion as a main material of uric acid production. Consequently, reduction in uric acid excretion may reduce the environmental contamination. On the other hand, in corn-fed birds, with an increase in microbial fermentation there would be more loss of nitrogen, leading to a reduction of apparent nitrogen digestibility, as was seen. This result agrees with the finding of Hevia and Clifford (1977) who demonstrated uric acid is the principle end product of nitrogen metabolism and its output becomes a measure of the net balance between de novo purine synthesis, purine degradation and purine reutilization. The relationship between dietary protein quality and total uric acid output (production) is also important, because it allows the estimation of dietary protein quality from measurements of uric acid which are simple, easy and inexpensive to obtain. The apparent metabolizable energy values are presented as means in Table 3. AME and AMEn value for barley, hulless barley and triticale based diets are the same as the corn based diet (P>0.05), but enzyme treatment of triticale-based diet and the hulled-based diet showed the highest and the lowest AME value amoung all experimental diets, respectively (P<0.05). Enzyme treatment of a particular grain increased the energy value about 15.5% (P=0.1269). It is important to note that the improvement in the AME of a particular grain treated by enzyme is due to the improvement in nutrient (protein, fat, etc.) digestibility but not due to the availability of NSP itself to act as an energy source for the chicken. This result agrees with the finding of other researchers (Danicke *et al*. 1995; Schutte *et al*. 1995) who demonstrated the same result by using wheat-based diets.

Blood serum metabolite

There were no significant difference between treatments in serum creatinin (Table 4). Triticale based-diet showed the highest and hulless barley-based diet showed the lowest value for serum cholsterol concentration amongst all the experimental diets (P<0.05). In this regards, lowest serum triacylglycerols value has been shown in hulless barley-based diet treated by enzyme. These effects have been attributed to many different mechanisms, including the ability of soluble dietary fibers to increase faecal excretion of bile acids thereby leading to an enhanced conversion of cholesterol to bile acids, which resulted in a reduction in the absorption of fat and cholesterol (Pettersson and Aman, 1992; Delaney *et al*. 2003). Furthermore, as a cholesterol fighter, a high ratio of arginine: lysine is also recommended (Braverman, 1997). It has been reported that with an equal crude protein content, triticale is richer in lysine than wheat and barley Gatel *et al*. (1985) and it may reduce the ratio of arginine:lysine as a cholesterol fighter in the triticale-based diet. This result agrees with the finding of other researchers who have mentioned that an increase in NSP in intestinal contents reduced cholesterol absorption and plasma cholesterol concentration in broiler chickens (Moharrery, 2006). The interest results have been shown on the serum immunoglobulin concentration (Table 4). A significant increase (P<0.05) in the serum immunoglobulin concentration was also observed in the chickens on hulled barley-based diet compared to the same diet treated with enzyme (2.16 times) or corn-based diet (3.06 times). We hypothesize that β-glucan may join the major histocompatibility complex (MHC) compound and subsequently activate monocytes or macrophages.

This action leads to subsequent immuno-potentiation, which may include the activation of cytotoxic macrophages, T-helper and natural killer cells, the promotion of T-cell proliferation and differentiation and the activation of the alternative complement pathway (Bohn and BeMiller, 1995). The concentration of immunoglobulin is an indicator of the response to exterior stimulation. In the present experiment, the increase in the concentration of serum IgG was most likely as a result of stimulation by dietary β-glucan in the hulled barley-based diet (treat no. 4). Enzyme treatment in the same diet (treat no. 7) resulted in the destruction of β-glucan in this diet; therefor the IgG concentration in the serum of the chickens on this diet was reduced markedly (2.16 times). The lowest value for IgG concentration was observed in the chickens on the corn-based diet, as corn is known to contain no β-glucan. The question arises as to why other grains, such as hulless barley or triticale, cannot produce the same result as hulled barley? In answer to this question it has been hypothesized that variation in the molecular weight, degree of branching, conformation, linkage, and intermolecular association in different grain species result in differing physical properties that affect the biological activity of β-glucan in animals (Bohn and BeMiller, 1995; Kulicke *et al*. 1997; Pins *et al*. 2005). No differences between sex in serum metabolite were found (P>0.05). In this regards, interaction between sex and treatment was not significant in any serum metabolites (P>0.05).

Carcass characteristics

The mean percentage of carcass parts in different treatments is depicted in Table 5. Fresh carcass yield was the lowest in chickens on triticale with no treatment (P<0.05). Except for the neck and liver, no significant effects of treatments on the carcass parts could be found. No differences between sex in carcass were found (P>0.05). In this regards, interaction between sex and treatment was also not significant in all carcasses traits (P>0.05).

Table 3 Mean values of calculated metabolizable energy and digestibility coefficients of diets

Metabolizable energy (kcal/kg)	Treatments							SEM	P*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
AME of total diet	2995	2998	2994	2764	3086	3171	2941	131.7	0.3902
AMEn of total diet	2880^{ab}	2845^{ab}	2857^{ab}	2646^{b}	2936^{ab}	3029^{a}	2823^{ab}	120.0	0.3955
AME of particular grain	3521^{a}	2948^{ab}	2936^{ab}	2277^{b}	3199^{ab}	3442^{a}	2785^{ab}	328.6	0.2235
Digestibility coefficients (%)									
Dry matter	69.25	73.39	72.50	66.75	74.45	74.28	68.04	3.09	0.2370
Protein[2]	47.68^{b}	60.36^{a}	55.26^{ab}	51.58^{ab}	59.31^{ab}	57.14^{ab}	51.82^{ab}	5.20	0.2613
Corrected protein[3]	79.63	85.61	86.51	76.89	84.69	84.14	71.63	5.84	0.5071
Ether extract	69.13^{b}	82.02^{ab}	78.27^{ab}	78.79^{ab}	88.09^{a}	88.12^{a}	88.64^{a}	4.55	0.0888

[1] (1): corn; (2): hulless barley; (3): triticale; (4): hulled barley; (5): hulless barley + enzyme; (6): triticale + enzyme and (7): hulled barley + enzyme.
[2] (nitrogen×6.25).
[3] Fecal nitrogen in the excreta was corrected as total nitrogen minus nitrogen in the uric acid.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 4 Some blood serum metabolites of chickens fed different cereal-based diets

	Treatments[1]							SEM	Sex			Intraction Sex × Treat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		Male	Female	P*	
	mg/dL											
Total cholesterol	77.9^{ab}	56.4^{b}	90.1^{a}	69.4^{ab}	85.7^{ab}	74.0^{ab}	80.0^{ab}	9.00	75.0	76.5	0.8826	0.9342
Triacylglycerols	45.4^{a}	31.2^{bc}	32.6^{bc}	35.5^{abc}	24.3^{c}	27.0^{bc}	38.6^{ab}	3.86	34.2	32.6	0.5840	0.8284
Glucose	226^{a}	218^{a}	144^{bc}	198^{ab}	175^{abc}	117^{c}	108^{c}	22.06	168	176	0.4562	0.4391
Creatinin	0.254	0.212	0.242	0.223	0.265	0.235	0.263	0.028	0.247	0.236	0.5970	0.7676
Immunoglobulin	13.8^{b}	22.5^{ab}	29.0^{ab}	42.2^{a}	31.1^{ab}	32.8^{ab}	19.5^{b}	6.40	26.8	29.4	0.3872	0.1436

[1] (1): corn; (2): hulless barley; (3): triticale; (4): hulled barley; (5): hulless barley + enzyme; (6): triticale + enzyme and (7): hulled barley + enzyme.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
* Probability.

Table 5 Effect of different treatment on yield of parts as a percentage of broiler carcass weight

	Treatments[1]							SEM	Sex			Intraction Sex × Treat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		Male	Female	P*	
	%											
Fresh carcass[2]	74.5^{a}	73.0^{ab}	70.2^{b}	71.9^{ab}	72.4^{ab}	73.6^{ab}	72.7^{ab}	1.12	73.2	72.1	0.2103	0.1306
Thigh	28.2	28.8	30.4	29.1	28.3	28.2	28.0	0.85	28.8	28.6	0.7790	0.4828
Breast	34.7	33.6	30.7	32.8	33.8	33.1	34.1	1.73	33.5	33.0	0.7452	0.7755
Wings	10.6	10.7	11.1	10.9	10.6	10.4	10.7	0.38	10.6	10.8	0.3649	0.8340
Neck	6.2^{b}	6.7^{ab}	6.9^{ab}	6.8^{ab}	6.6^{ab}	7.1^{a}	6.6^{ab}	0.27	6.7	6.7	0.8575	0.9293
Liver	1.87^{ab}	1.81^{b}	1.88^{ab}	2.03^{a}	1.80^{b}	1.91^{ab}	1.79^{b}	0.05	1.82	1.92	0.0243	0.3985

[1] (1): corn; (2): hulless barley; (3): triticale; (4): hulled barley; (5): hulless barley + enzyme; (6): triticale + enzyme and (7): hulled barley + enzyme.
[2] Carcass yields as percentages of live weight.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
* Probability.

We can not explain the findings for the neck, but the reason for higher significant liver percentage in chicken on hulled barley-based diet (treat no. 4) compared with the same diet but treated with enzyme (treat no. 7) can be explained by soluble dietary fibers in hulled barley (treat no. 4), which increase faecal excretion of bile acids, thereby leading to an enhanced liver for conversion of substrate such as cholesterol to bile acids (Pettersson and Aman, 1992; Delaney *et al*. 2003). Higher activity of liver causes an increase in size of this organ in hulled barley (treat no. 4) and degradation of soluble dietary fibers by supplementation of enzyme to hulled barley-based diet (treat no. 7), caused the liver metabolism to show the normal activity and to find lower liver percentage compared to untreated hulled barley-based diet (treat no. 4).

But further work is needed to detect all aspects of liver size variation due to different diet consumption in broiler chicken.

CONCLUSION

Production performance like final body weight, total gain, and feed conversion ratio were statistically higher in chicken on enzyme treated diets during 14 to 42 days old, but it will become to no more difference with aged chicken (14 to 56 days old) among all cereal, when the capacity of alimentary tract as well as digestibility performance increase. It was therefore concluded that there was no apparent risk of using triticale or hulless barley based diet at any proportion (up to 35% of the diets) in the broiler diet to ov-

er that of corn based ones on the productive performance.

ACKNOWLEDGEMENT

The financial support of Research Department of Shahrekord University is gratefully acknowledged.

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IJAS Iranian Journal of Applied Animal Science

بررسی عملکرد جوجه‌های گوشتی مصرف کننده جیره‌های بر پایه جو و تریتیکاله

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چکیده

این پژوهش بر روی جوجه‌های گوشتی (۱۴ تا ۵۶ روزه) به منظور بررسی تأثیر جیره‌های بر پایه جو و تریتیکاله انجام پذیرفت. جیره‌های تحت آزمون شامل: جیره حاوی ذرت به عنوان شاهد (۱)، جیره حاوی جو بدون پوشینه با (۵) و یا بدون افزودن آنزیم (۲)، جیره حاوی تریتیکاله با (۶) و یا بدون افزودن آنزیم (۳) و جیره حاوی جو معمولی با (۷) و یا بدون افزودن آنزیم (۴) بودند. آنزیم مورد استفاده حاوی بتاگلوکاناز بود. در آزمایش تعیین قابلیت هضم از ۲۱ قطعه جوجه در سن ۴۵ روزگی استفاده شد. برای ۷ جیره تحت آزمون ۳ تکرار در نظر گرفته شد. برای صفات افزایش وزن روزانه و خوراک مصرفی در طی دوره رشد هیچ تفاوت معنی داری بین جیره‌های ۲ تا ۷ و جیره شاهد مشاهده نشد ($P>0/05$). جو معمولی (۴) کمترین افزایش وزن و بیشترین ضریب تبدیل (بازده کم) را نسبت به بقیه جیره‌ها نشان داد. قابلیت هضم عصاره اتری در تمام جیره‌های حاوی آنزیم بیشتر از جیره شاهد بدست آمد ($P<0/05$). همچنین انرژی قابل متابولیسم ظاهری (AMEn) در جیره (۴) نسبت به جیره‌های (۱) و (۶) کمتر بود ($P<0/05$). اما کلسترول سرم خون جوجه‌های مصرف کننده جیره (۴) کمتر از بقیه بدست آمد ($P<0/05$) ولی در غلظت کراتینین سرم خون تفاوتی بین تیمارها مشاهده نشد ($P>0/05$). با این وجود، غلظت ایمینوگلوبولین سرم خون جوجه‌های تیمار (۴) نسبت به جیره‌های (۷) و (۱) در بیشترین اندازه بود ($P<0/05$). وزن لاشه تازه نیز در جوجه های مصرف کننده جیره (۳) کمترین مقدار و در صد کبد در جوجه‌های مصرف کننده جیره (۴) در بیشترین مقدار مشاهده گردید ($P<0/05$). از نتایج این پژوهش می‌توان اینگونه نتیجه گرفت که مکمل نمودن آنزیم در جیره‌ها می‌تواند در سن ۱۴ الی ۴۲ روزگی تأثیر مثبت بر افزایش وزن، خوراک مصرفی و ضریب تبدیل داشته باشد، اما این مزیت با افزایش سن جوجه‌ها به تدریج کاهش می‌یابد که علت آن افزایش قابلیت هضم و ظرفیت دستگاه گوارش با افزایش سن جوجه‌ها است.

کلمات کلیدی جو، جوجه گوشتی، قابلیت هضم، آنزیم، عملکرد رشد، جو بدون پوشینه، تریتیکاله.