Journal of Agricultural Technology 2012 Vol. 8(3): 825-836
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Effect of various level of treated barley on small intestinal content viscosity, litter moisture, uric acid and broiler chickens performance

A.A. Saki[1*], S. Mirzayi[1], Sh. Ghazi[2], M.M. Moini[2], R. Naseri Harsini[1], M. Haghighat[1], R. Mahdavi[2]

[1]Department of Animal Science, Faculty of Agriculture, Bu Ali Sina University, Hamedan-Iran,
[2]Department of Animal Science Razi University, Kermanshah-Iran

A.A. Saki, S. Mirzayi, Sh. Ghazi, M.M. Moini, R. Naseri Harsini, M. Haghighat, R. Mahdavi (2012) Effect of various level of treated barley on small intestinal content viscosity, litter moisture, uric acid and broiler chickens performance. Journal of Agricultural Technology 8(3): 825-836.

Barley is one of the energy sources for broiler chicken nutrition but the presence of non Starch Polysaccharide (NSP), particularly high viscosity *β*-glucan, can decrease nutrient digestibility. Eight hundred day-old unsexed *Arbor Acres* chickens were allocated to one of four replicates of the 8 treatments employed at 10 days of age following feeding of a common pre-starter diet. Experimental design was 4(×) 2 factorial arrangement with four levels barley (0, 10, 20 and 30%), and 2 levels Grind enzyme (0, 0.5 kg/ton). Viscosity for 30% barley at 21 and 42 days of age were significantly higher ($P < 0.05$). Viscosity was decreased by enzyme inclusion at 42 days of age. Increased litter moisture (44.98%) was observed by 30% barley in comparison to other treatments; in contrast, this parameter was significantly reduced by enzyme supplementation. Similar trend was observed in litter uric acid. Bird's growth rate was significantly lower in 30% barley at 21 and 42 d of age. The inclusion of 0.5 kg/ton enzyme in the chicken's diet resulted in a significant increase in the growth rate at 10-21 days of age. Feed to gain ratio of birds fed 30% barley diet was inferior than birds fed other treatments during experiment.

Key words: Broiler chicken, Barley, Viscosity, Litter moisture, Litter uric acid, Performance

Introduction

Intestinal physiology, morphology and ecosystem of gastrointestinal tract could be changed by viscosity and this may lead to unfavorable effects on nutrient solubility and non Starch Polysaccharide (NSP), digestion and absorption in broiler chicken. High viscosity is the principle factor that increases anti-nutritive activity of these nutrients, which may have negative effect on poultry performance (Combell *et al*. 1993). In fact soluble NSP

* Corresponding author: A.A. Saki; e-mail: dralisaki@yahoo.com

reaction by membrane glycocalyx may cause an increase in mucosal layer thickness and finally reduction of nutrient absorption (Marquardt *et al*., 1983). Viscosity is the main factor in extracting anti nutrient effect of soluble NSP characteristics since breaking NSP molecule to small polymer by enzyme could reduce viscosity and increase feed value (Annison, 1991). Apart from the direct physical effects of viscosity in the gastrointestinal tract, a relatively higher intestinal viscosity has a number of indirect negative effects on the nutritive value of poultry diets. These effects include reduced rate of feed passage, litter management problems and increased water consumption (Bedford, 2002). Choct and Annison (1992a) reported that in spite of the addition of non depolymerised NSP to broiler diet when depolymerised NSP was added to broiler diet, severe anti nutrient effects weren't observed. The gel-forming cell wall polysaccharides are hydrolyzed with the addition of enzyme and decrease litter moisture compared with normal condition. In broiler, uric acid is a major end product of protein metabolism (Wright, 1995). This compound makes up 60-82% of urine nitrogen (Marquardt *et al*. 1983). Measuring protein digestibility by using biological method by mixing fecal and urine in broiler is very complex. The amount of excreted uric acid used as an index to determine diet protein quality in broiler chickens, the lower excretion of uric acid measurement shows the higher protein quality.

Although, different experiments were arranged to determine barley viscosity in GI worldwide, viscosity is affected by some factors such as climate, the time of harvest, soil type, cereal's species, and geographical condition (Carias *et al*. 1998) which was considerably different in our region state (Hamedan province) and country (IRAN) compared to the rest of the world. Therefore, the objective of the present study was to determine the effect of different levels of native treated barley content viscosity of the small intestine, litter moisture, uric acid and performance (feed intake, growth rate and feed to gain) in broiler chickens.

Material and methods

In this experiment eight hundred day old unsexed *Arbor Acres* broiler chicks were transported from a commercial hatchery to the poultry research farm at the Bu-Ali Sina University on January 20, 2008 (d 1); and animal care committee in Bu-Ali Sina University confirmed this experiment. Chicks were placed on wood shavings litter in environmentally controlled chambers. The temperature and lighting regime were arranged based on *Arbor Acres* commercial broiler chicken requirement (2006). Chicks were fed a commercial starter diet for a 10-d pre-experimental period and, after 4 h of feed deprivation, were randomly distributed into experimental groups (four replicates of eight

treatments) in such a way that all groups had the similar average weight. All diets were given in mash form with birds having free access to water and feed throughout the experiment.

Dry matter, crude protein, ether extract, crude fiber, and ash contents of ingredients (Corn, Soybean meal, Barley, and Fish meal) were determined by methods according to the Association of Official Analytical Chemists (AOAC, 1990). The Crude protein and Metabolizable energy contents of starter and grower diets were 21.55, 2950, and 18.51, 2950, respectively. Diets compositions in starter and grower phases were arranged based on *Arbor Acres* recommended requirements (Tables 1, and 2, respectively). The crude enzyme preparation used in this study was Grind enzyme (a commercial multienzyme complex produced from a selected strain of *Aspergillus niger* that hydrolyzes a broad range of carbohydrates). The supplier reported that crude enzyme contained endo-1, 3 (Bedford *et al*. 2000) *β*-glucanase (6000 U/g), and endo-1,4-*β*-xylanase (12000 U/g). The activity of each enzyme was determined by the supplier according to the Nelson-Somogyi method for the determination of reducing sugar content (Somogyi, 1960). The enzyme preparation was added directly to other ingredients according to the supplier's recommendations.

Table 1. Ingredients and nutrient composition of diets in starter phase

	Diet (%)							
Ingredient	A	B	C	D	E	F	G	H
Corn	60.62	60.67	49.99	50.04	39.35	39.4	28.71	27.76
Soybean meal	30.59	30.59	30.23	30.23	29.88	29.88	29.52	29.52
Soybean oil	1.13	1.13	2.15	2.15	3.16	3.16	4.18	4.18
Barley	-	-	10.00	10.00	20.00	20.00	30.00	30.00
Fish meal	4.8	4.80	4.80	4.80	4.80	4.80	4.80	4.80
Oyster shell	1.05	1.05	1.08	1.08	1.10	1.10	1.12	1.12
Dicalcium phosphate	0.81	0.81	0.77	0.77	0.73	0.73	0.69	0.69
Salt	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33
Vitamin mix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral mix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
D-L Methionine	0.1	0.10	0.10	0.10	0.10	0.10	0.11	0.11
Enzyme[3]	0.5	-	0.50	-	0.50	-	0.50	-
Calculated composition								
ME (kcal/kg)	2950	2950	2950	2950	2950	2950	2950	2950
CP (%)	21.55	21.55	21.55	21.55	21.55	21.55	21.55	21.55
Ca[4] (%)	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
NPP[5] (%)	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Lys (%)	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
Met + Cys (%)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Analyzed composition								
Dry matter	91.1	90.90	91.40	90.90	91.90	91.70	92.40	92.20
Crude protein	21.23	21.20	21.12	21.10	21.01	21.00	20.90	20.75
Ether extract	4.39	4.90	5.20	5.60	6.30	6.91	7.10	7.40
Crude fiber	1.45	1.60	2.02	2.10	3.40	3.70	4.20	4.35
Ash	5.48	5.83	5.47	5.61	5.44	5.77	5.85	6.06

A: Control with enzyme. B: control without enzyme. C: 10% barley with enzyme. D: 10% barley without enzyme. E: 20% barley with enzyme. F: 20% barley without enzyme. G: 30% barley with enzyme. H: 30% barley without enzyme.

[1]Supplied per kg of vitamin mixture : Vitamin A: 7.2gr; Vitamin D: 7. gr; Vitamin E: 14.4gr; Vitamin K3: 1.6gr; Vitamin B1: 0.72gr; Riboflavin: 3.3gr, Pantothenic acid: 12gr, niacin: 12160 mg; Vitamin B6: 6.2 mg; Biotin: 0.2 gr; Vitamin B12 - 0.6 gr; choline chloride 440. [2] Supplied per kg of mineral mixture: manganese (oxide): 64 gr; iron (FeSO4) -100 gr; zinc (oxide): 44 gr; copper (CuSO4):16 gr; iodine (calcium iodate): 64 gr; selenium (1%): 8 gr; cobalt :0.2 gr. [3]Based upon company's suggestion 0.5 kg/ton was added. [4]alculated from tabular values (NRC, 1994). [5]NPP, nonphytate P.

Table 2. Ingredients and nutrient composition of diets in grower phase

Ingredient	**Diet**							
	A	B	C	D	E	F	G	H
	(%)							
Corn	67.86	67.91	59.22	59.27	48.71	48.76	38.21	38.26
Soybean meal	26.19	26.19	24.71	24.71	24.24	24.24	23.77	23.77
Soybean oil	0.40	0.40	0.76	0.76	1.76	1.76	2.75	2.75
Barley	-	-	10.00	10.00	20.00	20.00	30.00	30.00
Fish meal	2.02	2.02	2.50	2.50	2.50	2.50	2.50	2.50
Oyster shell	0.88	1.31	1.10	1.10	1.12	1.12	1.15	1.15
Dicalcium phosphate	1.33	1.33	0.85	0.85	0.81	0.81	0.77	0.77
Salt	0.28	0.28	0.27	0.27	0.26	0.26	0.26	0.26
Vitamin mix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral mix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
D-L Methionine	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Enzyme[3]	0.50	-	0.50	-	0.50	-	0.50	-
Calculated composition								
ME (kcal/kg)	2950	2950	2950	2950	2950	2950	2950	2950
CP (%)	18.51	18.51	18.51	18.51	18.51	18.51	18.51	18.51
Ca[4] (%)	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
NPP[5] (%)	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Lys (%)	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Met + Cys (%)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Analyzed composition								
Dry matter	90.80	90.70	91.30	90.80	90.80	90.70	91.20	91.10
Crude protein	18.40	18.33	18.30	18.25	18.23	18.20	18.20	18.15
Ether extract	4.05	4.10	4.25	4.55	4.85	5.18	5.35	5.75

Crude fiber	1.50	1.62	2.30	2.50	4.10	4.15	6.49	6.68
Ash	6.49	6.92	5.94	6.24	6.29	5.84	5.26	6.69

A: Control with enzyme. B: control without enzyme. C: 10% barley with enzyme. D: 10% barley without enzyme. E: 20% barley with enzyme. F: 20% barley without enzyme. G: 30% barley with enzyme. H: 30% barley without enzyme.

[1]Supplied per kg of mixture vitamin : Vitamin A: 7.2gr; Vitamin D: 7. gr; Vitamin E: 14.4gr; Vitamin K3: 1.6gr; Vitamin B1: 0.72gr; Riboflavin: 3.3gr, Pantothenic acid: 12gr, niacin: 12160 mg; Vitamin B6: 6.2 mg; Biotin: 0.2 gr; Vitamin B12 - 0.6 gr; choline chloride 440. [2] Supplied per kg of mixture mineral: manganese (oxide): 64 gr; iron (FeSO4) -100 gr; zinc (oxide): 44 gr; copper (CuSO4):16 gr; iodine (calcium iodate):.64 gr; selenium (1%): 8 gr; cobalt: 0.2 gr.

[3]Based upon company's suggestion 0.5 kg/ton was added. [4]alculated from tabular values (NRC, 1994). [5]NPP, nonphytate P.

For viscosity verifying, in the end of 21 and 42 days, two chicks from each replicate were randomly chosen and euthanized. The body cavity was opened, and the contents of the jejunum (from duodenum to the Meckel's diverticulum), ileum (from the Meckel's diverticulum to 4 cm above the ileo-caecal junction), and ceca were collected separately. Digesta from 2 birds of each replicate were pooled, and fresh weights were recorded. Digesta were centrifuged (12000 (×) g, 10 min, 4°C). Supernatant and pellet from each pooled sample were frozen and stored at –20°C for future analysis. Viscosities of thawed supernatants were measured with stowald viscometer.

To determine moisture and uric acid contents of litter, three samples of each pen were randomly chosen (subsequent samplings were taken from the same location of first sampling in all pens). Moisture content of the samples was determined by drying the samples at 105°C for 16h. Uric acid content of litter was measured by methods described by Marquardt *et al*. (1983).

Feed consumption, growth rate, and feed conversion ratio were measured at 21 and 42 days of age. Mortality was recorded daily, and feed conversion was corrected for mortality by adding weight gain of dead birds (weighed or culled daily) to gains of live birds at end of the experiment.

The experiment was designed and statistically analyzed as a 2×4 factorial arrangement of two levels of enzyme and four levels of barley. Body weight of 10d was used as a covariate. The following statistical model (SAS, 2004) was used to assess the main effect of diet (S), the main effect of enzyme (D) and the corresponding interaction S (×) D:-

$$Y_{ijk} = \mu + S_i + D_j + S_i\ D_j + e_{ijk}$$

Where Y_{ijk}, observed trait; μ, overall mean; S_i, effect of diet; D_j, effect of enzyme; S_i (×) D_j, interaction of D_j and S_i; and e_{ijk}, random error.

Duncan's multiple-range test was used to determine significant difference among treatment means.

Results

Higher significant viscosity was shown by 30% level of barley (1.88 centipoises) compared with other treatments in starter period ($P < 0.05$). In contrast, no response was found by 20%, and 30% barley in diet which supplemented by enzyme (0.5 kg/ton) ($P < 0.05$). Viscosity was influenced by various levels of enzyme at the end of the experimental period, since chicken fed diets supplemented by enzyme have shown significant lower viscosity (1.49 centipoises) in comparison to other treatments (Table 3). A significant barley (×) enzyme interaction effect on intestinal viscosity was observed in 42d of age ($P < 0.0001$), since higher viscosity was shown by 30% barley in absence of enzyme supplementation ($P < 0.05$). However in 21d of age this interaction was not significant.

Table 3. Intestine viscosity in response to barley rations (centipoises)

Source of variation	**days**		
	Diet (%)	21	42
Barley (S)	0	1.51^{b}	1.33^{d}
	10	1.60^{b}	1.43^{c}
	20	1.60^{b}	1.54^{b}
	30	1.88^{a}	1.79^{a}
	P	0.0078	<0.0001
Enzyme (D)	0	1.66^{a}	1.55^{a}
	0.5	1.63^{a}	1.49^{b}
	P	0.0582	<0.0001
S (×) D	P	0.0918	<0.0001
Combination effects			
Barley (×) enzyme	0×0.5	1.50 ± 0.05^{c}	1.31 ± 0.04^{f}
	0×0	1.52 ± 0.05^{c}	1.34 ± 0.05^{f}
	10×0.5	1.59 ± 0.05^{bc}	1.41 ± 0.05^{e}
	10×0	1.60 ± 0.05^{bc}	1.44 ± 0.06^{e}
	20×0.5	1.72 ± 0.03^{abc}	1.51 ± 0.05^{d}
	20×0	1.48 ± 0.04^{c}	1.56 ± 0.06^{c}
	30×0.5	1.85 ± 0.03^{ab}	1.73 ± 0.04^{b}
	30×0	1.92 ± 0.03^{a}	1.85 ± 0.03^{a}
	P	0.0190	0.0001
	MSE	0.0233	0.0004

Means in a column bearing different superscripts are significantly different ($P<0.05$).

Litter uric acid decreased by enzyme supplementation but this reduction was not significant ($P > 0.05$). In this experiment excreted uric acid significantly increased by 30% barley (7.07%) ($P < 0.05$, Table 4).

In this study litter moisture (44.98%) was significantly higher in 30% barley diet compared to other diets at the end of experiment ($P < 0.05$, Table 4). Enzyme supplemented significantly decreased litter moisture (29.79%). The barley (×) enzyme interaction for litter moisture in 42d of age was significant ($P = 0.0046$).

Table 4. Litter uric acid and moisture in response to barley rations

Source of variation	Diet (%)	Uric acid (%)	Moisture (%)
Barley (S)	0	3.20^{c}	29.50^{bc}
	10	5.22^{b}	25.80^{c}
	20	5.72^{b}	31.30^{b}
	30	7.07^{a}	44.98^{a}
	P	<0.0001	0.0001
Enzyme (D)	0	5.44^{a}	36.00^{a}
	0.5	5.00^{a}	29.79^{b}
	P	0.1517	<0.0001
S(×) D	P	0.0744	0.0046
Combination effects			
Barley (×) enzyme	0×0.5	2.80 ± 0.44^{c}	28.00 ± 7.75^{dc}
	0×0	3.61 ± 0.2^{c}	31.00 ± 2.48^{bc}
	10×0.5	5.34 ± 0.48^{b}	23.73 ± 1.74^{d}
	10×0	5.09 ± 0.81^{b}	$27.86\pm0.7d^{c}$
	20×0.5	5.69 ± 0.07^{b}	30.00 ± 1.10^{dc}
	20×0	5.75 ± 0.06^{b}	32.60 ± 0.88^{bc}
	30×0.5	6.75 ± 0.7^{a}	37.43 ± 5.12^{b}
	30×0	7.29 ± 0.81^{a}	52.53 ± 4.00^{a}
	P	0.0001	0.0001
	MSE	0.2735	14.28

Means in a column bearing different superscripts are significantly different (P<0.05)

Feed intake was not affected by treatments at 21 days of age. In addition the lowest feed intake was seen with the 30% barley diet at 22-42 days of age ($P < 0.05$) (Table 5). In the same manner, enzyme inclusion could not affect feed intake. No significant interaction was found between barley and enzyme on feed intake. Growth rate was significantly lower for birds fed the 30% barley diets compared with all other treatments at 21 and 42 d of age ($P < 0.05$). The inclusion of 0.5 kg/ton enzyme in the diet of chicken resulted in a significant increase ($P < 0.05$) in the 10-21d growth rate compared to no enzyme supplemented diets. Interaction between barley and enzyme was significant

only in 10-21d of age (P = 0.0019). The feed intake (2604.17g) and growth rate (1140.83g) of the growing broiler chicken were reduced by 30% barley (P < 0.05) (Table 5). Feed to gain ratio of birds fed 30% barley diet was inferior (P < 0.05) than birds fed other treatments during whole experiment. Diets supplementation with enzyme significantly improved FCR in all phases of the study (P < 0.05). Interactions between barley and enzyme was significant for FCR in starter (P = 0.0001) and grower periods (P = 0.0001). Such findings, confirmed by Supplementation with the Grind enzyme did not significantly increase feed intake in all treatments (Table 5) but, improve growth rate in the 10-21 days of age (465.66g).

Table 5. Effect of different levels of barley and enzyme on performance of broilers chicken

Source of variation	Diet (%)	Feed intake (g)		Growth Rate (g)		FCR	
		10-21	22-42	10-21	22-42	10-21	22-42
Barley (S)	0	712.66^{a}	2750.00^{a}	500.83^{a}	1432.67^{a}	1.42^{c}	1. 92^{c}
	10	661. 00^{a}	2634.17^{ab}	490.00^{a}	1407.83^{a}	1.41^{c}	1.87^{d}
	20	697.66^{a}	2685.17^{ab}	442.66^{b}	1287.67^{b}	1.57^{b}	2.08^{b}
	30	712.66^{a}	2604.17^{b}	403.33^{c}	1140.83^{c}	1.76^{a}	2.28^{a}
	P	0.1517	0.0046	0.0001	0.0001	0.0001	<0.0001
Enzyme (D)	0	703.08^{a}	2679.83^{a}	452.75^{b}	1314.33^{a}	1.56^{a}	2.05^{a}
	0.5	688.92^{a}	2656.92^{a}	465.66^{a}	1320.17^{a}	1.52^{b}	2.02^{b}
	P	0.0723	0.1434	0.0001	0.1294	0.0054	0.0107
S × D	P	0.2117	0.0635	0.0019	0.0522	0.0001	0.0001
Combination effects							
Barley × enzyme	0×0.5	714.33±18.71^{ab}	2733.33±172.43^{ab}	507.00±7.81^{a}	1426.33±90.00^{a}	1.40±0.01^{d}	1.91±0.01^{d}
	0×0	711.00±15.58^{ab}	2766.66±133.16^{a}	494.66±12.85^{ab}	1439.00±76.62^{a}	1.43±0.01^{d}	1.92±0.08^{d}
	10×0.5	719.33±12.23^{ab}	2714.33±72.39^{ab}	497.00±10.00^{ab}	1419.00±48.00^{a}	1.40±0.03^{d}	1.91±0.04^{d}
	10×0	693.00±7.49^{ab}	2554.00±60.23^{b}	483.00±7.00^{b}	1396.66±42.09^{a}	1.43±0.01^{d}	1.82±0.02^{e}
	20×0.5	693.00±7.49^{ab}	2641.33±89.47^{ab}	444.66±6.11^{c}	1285.33±48.39^{b}	1.55±0.02^{c}	2.05±0.01^{c}
	20×0	702.33±8/62^{ab}	2729.00±97.96^{ab}	440.66±9.29^{c}	1290.00±35.79^{b}	1.59±0.02^{c}	2.11±0.02^{c}
	30×0.5	629.00.±25/10^{ab}	2538.66±97.21^{b}	414.00±14.73^{d}	1150.00±32.60^{c}	1.73±0.01^{b}	2.20±0.02^{b}
	30×0	706.00±14/73^{ab}	2669.66±104.22^{ab}	392.66±9.29^{e}	1131.66±43.00^{c}	1.79±0.01^{a}	2.36±0.02^{a}
	P	0.3661	0.1499	0.0001	0.0001	0.0001	0.0001
	MSE	2085.87	1781.37	0.0004	0.001	100.29	3072.91

Discussion

Increase of intestinal viscosity by high level of barley and decrease by enzyme supplementation are in agreement with previous reports by Garcia *et al*. (1997), Fuente *et al*. (1998), Leeson and Caston (2000) and Gracia *et al*. (2003). Leeson and Caston (2000) suggested that although viscosity of the intestinal contents was reduced by enzyme-supplement in birds, when compared to the control (non-supplemented diet), only viscosity measured at 6 wk differed significantly ($P < 0.01$). Data displayed a trend an increased intestinal viscosity as the level of barley increased. Viscosity (1.88 cp) in 30% barley was significantly higher than other treatments but, significantly decreased viscosity (1.49cp) was obtained by enzyme supplementation at 42 days of age ($P < 0.05$) (Table 3). Intestinal nutrient digestion and absorption and eventually broiler performance were depressed by increased viscosity and sticky digesta. Almiral *et al*. (1995) suggested that increasing viscosity which results in reduction of physical potential of mixing in gut and low distribution of feed in gastrointestinal tract may effect endogenous enzyme activity, changing microflora population and also renewal intestinal cells. Bedford (2000) suggested that Predominant interaction between intestinal microflora and viscosity increased unsuitable fermentation in jejunum and ileum and leads to unavailability of nutrients for the birds. Decrease in nutrient absorption occurred by beta glucan with water absorptive in their gel molecules, this could be linked with glycocalyx in the intestinal villi and leads to decrease of feed intake.

Our finding is in close agreement with Marquardt *et al*. (1983) reports. Litter uric acid was significantly higher by 30% barley without enzyme treatment (7.29%, $P < 0.05$). Interaction between barley and enzyme was not significant for litter uric acid. Uric acid constitutes 60-82% total urine nitrogen in poultry and lower excretion of uric acid measurement show the higher protein source quality. Declining uric acid by enzyme supplementation could be related to more availability and digestibility of protein and therefore eliminates nitrogen excretion as a main content of uric acid production. Consequently reduction in uric acid excretion may reduce environmental contamination. This observation could be related to enzyme utilization of feed nitrogen by intensification of the protein digestibility. Therefore, lower amount of nitrogen as a result of amino acid metabolism is excreted in urine and finally in litter content. This subject could help to reduce ammonia in litter and improve of farm environment. The results of excreta digestibility of protein based on uric acid clearly indicated this method is not only much easier and cheaper to

perform but results are similar in value in comparison to ileal digestibility of protein.

Increasing barley in the diet significantly increased litter caking, especially at the 30% level. This caking could present a management problem and possibly lead to foot and leg problems associated with wet and caked litter (Brake, 1997). Barley β-glucan is soluble and has a gel nature, this antinutrient increase water intake and produces sticky feces which maintain moisture on litter and cause lower performance. Adding enzyme to barley diets may overcome the problem of producing wet litter. Hydrolysis of the beta glucan, decreases the Non Starch Polysaccharide, water intake and eventually reduction of litter moisture may occur by enzyme inclusion (Chesson, 1993; Yu, 1998). These results are in agreement with three of the experiments conducted by Chesson (1993) and Yu *et al*. (1998). Leeson and Caston (2000) reported that litter moisture measured at 17 days was not affected by enzyme, although at 42 days litter moisture was significantly higher for the non-enzyme supplemented diets.

Other researchers (Marquardt *et al*. 1983; Almiral *et al*. 1995 Bennett *et al*. 2002) suggested that barleys enzyme improved FCR. Choct (2001) suggested that there is high positive correlation between FCR and intestinal viscosity since increasing viscosity could depress FCR as well as poultry production, our findings confirmed these results. Finding in feed intake are in agreement with results of Garcia *et al*. (1997), Leeson and Caston (2000), Gracia *et al*. (2003). Choct and Annison (Choct and Annison, 1990 Choct and Annison, 1992b) found that addition of enzymes to a barley based diet increases the utilization of nutrients and the energy value of the feed, while reducing intestinal viscosity, similar to the results of current experiment. Therefore reduction of viscosity by enzyme reaction is one of the reasons for higher performance. Choct (2001) Jeroch and Danicke (1995) findings are corresponding to the results of this study, since lowest performance was shown by 30% barley. The lower performance by 30% barley diet may be related to higher soluble fiber than other levels, the protein digestibility depressed by fiber content of barley, this indigestible protein fraction in barley may be due to protein bound fiber (Simbaya *et al*. 1996).

Acknowledgements

Our special thanks of Bu-Ali Sina University for providing facilities and financial support for this study. We also wish to thank to the staff of the Department of Animal Science of this university for their excellent scientific collaboration.

References

Almiral, M., M. Francesh, A.M. Preze-Vendrell, J. Brufa and E. Estive-Garcia (1995). The difference in intestinal viscosity produced by barley and beta-glucanase alter digesta enzyme activites and ileal nutrient digestibilities more in broiler chicks than in cocks. American Institute of Nutrition 125(4):947-954.

Annison, G. 1991. Relationship between levels of soluble non starch polysaccharides and the apparent Metabolizable energy of wheats assayed in broiler chickens. J. Agriculture Food Chemistry 39:1252-1256.

Association of Official Analytical Chemists (AOAC). Official Methods of Analysis. 1990 15th ed. K. Herlich, ed. Association of Official Analytical Chemist, Arlington, VA.

Bedford, M.R. 2000. Reduced viscosity of intestinal digesta and enhanced nutrition digestibility in chicken given exogenous enzyme. In Enzymes in Poultry and Swine Nutrition. Edited by Ronald R. Marquardt and Zhengkang Han. 2000 IDRc. CRDi publishing.

Bedford, M.R. 2002. The role of carbohydrase in feedstuff digestion. In: McNab supply, Composition and nutritive value. 2002. Pp:319-336 (Walling Ford, CAB International).

Bennett, C.D., H.L. Classen and C. Riddell 2002. Feeding broiler chickens wheat and barley diets containing whole, ground and pelleted grain. Poultry Science 81:995-1003.

Brake, J.D. 1997. Barley without enzyme supplementation in broiler grower and finisher diets. J. Apply Poultry Research 6:422-431.

Carias, D.A., M. Cioccia and P. Hevia 1998. Effect of food intake on protein quality measured in chicks by traditional or biochemical method of analysis. 15th. ed. Association of Official Analytical Chemists (AOAC), Washington, D.C.

Chesson, A. 1993. Feed enzymes. Anim. Feed Sci. Technol. 45:65-79.

Choct, M. and G. Annison 1992a. Anti nutritive effect of wheat pentosans in broiler chickens roles of viscosity and Gut microflora. British Poultry Science 33:821-834.

Choct, M. and G. Annison 1992b. The inhibition of nutrient digestion by wheat pentosans. British Journal of Nutrition 67:123-132.

Choct, M. and G. Annison 1990 Anti nutritive activity of wheat pentosanase in broiler diets. British Poultry Science 31:811-821.

Choct, M. 2001. Enzyme supplementation of poultry diets based on viscouse cereals in enzymes in farm animal nutrition Edited by M.R. Bedford and G.G. Partridge. CABI Publishing.

Fuente, J.M., P.P. De Ayala, A. Flores and M.J. Villamide. 1998. Effect of storage time and dietary enzyme on the metabolizable energy and Digesta Viscosity of Barley-Based Diets for Poultry. Poultry Science 77:90-97.

Garcia. E.E., J. Brufau, A. Perz-Vendrell, A. Miquel and K. Duven. 1997. Bioefficacy of enzyme preparations containing b-glucanase and xylanase activities in broiler diets based on barley or wheat, in combination with flavomycin. Poultry Research 76:1728-1737.

Gracia, M.I., M.A. Latorre, M. Garcı´a, R. La´zaro and G.G. Mateos. 2003. Heat processing of barley and enzyme supplementation of diets for broilers. Poultry Science (82):1281-1291.

Jeroch, H. and S. Danicke. 1995. Barley in poultry feeding : a review. World`s Poultry Science Journal 51(3):271-291.

Leeson, S. and L, Caston. 2000. Commercial enzymes and their influence on broiler fed wheat or barley. Journal of Apply Poultry. Research 9:242-251.

Marquardt, R.R., A.T. Ward and L.D.A. Campbell. 1983. Rapid high performance liquid chromatographic method for the quantification of uric acid in excreta and tissue sample. Poultry Science 62:2099-2105.

SAS User's Guide.2004.Version 8 ed. SAS Inst. Inc., Cary, NC.

Simbaya, J., B.A. Slominski, W. Guenter, A. Morgan and L.D. Campbell. 1996. The effects of protease and carbohydrase supplementation on the nutritive value of canola meal for poultry: *in vitro* and in vivo studies. Animal feed Science and Technology 61:219-234.

Somogyi, M. 1960. Modification of two methods for the assay of amylase. Clinical Chemistry 6:23-35.

Wright, P.A. 1995. Nitrogen excretion: three end products, many physiological roles (Review). Journal of Experimental Biology 198:273-281.

Yu Bi, J. Chung Hsuand and P.W.S., Chiou. 1998. Effects of beta glucanase supplementation of barley diets on growth performance of broilers. Animal feed and Technology 70:353-361.

(Published in May 2012)