EFFECTS OF INCLUSION OF HULL-LESS BARLEY AND ENZYME SUPPLEMENTATION OF BROILER DIETS ON GROWTH PERFORMANCE, NUTRIENT DIGESTION AND DIETARY METABOLISABLE ENERGY CONTENT

Seyed Davood SHARIFI[1], Farid SHARIATMADARI[2] and Akbar YAGHOBFAR[3]

[1] Department of Animal and Poultry Science, College of Abouraihan, University of Tehran, Pakdasht, Tehran, Postal code: 3391653755, Iran, Tel. & Fax: +98(21)36040907,
Email: sdsharifi@ut.ac.ir *Correspondence.

[2] Department of Animal Science, Faculty of Agriculture, Tarbiat Modarres University, Tehran, Iran.

[3] Department of Animal Physiology and Nutrition, Animal Science Research Institute, Karaj, Alborz, Iran.

ABSTRACT

Two trials were conducted to study the effect of inclusion of hull-less barley and exogenous enzyme to broiler diet on the growth performance, apparent metabolisable energy (AME) and Nutrient digestibility of broiler chickens. The experiments were 3×4 factorial arrangements with three levels of enzyme (0, 300 and 600 g/ton) and four levels of hull-less barley inclusion (0, 10, 20 and 30%) in diet. The digestion trial was performed in battery cage with 648 male broiler chickens where twelve experimental diets were fed to the chickens from 15-21 (starter) and 35-45 (finisher) days of age. In the growth trial, the experimental diets were fed to 960 broiler chicks distributed in 48 pens for a 7-week feeding trial on growing (0-3 weeks), grower (4-5 weeks) and finisher (6-7 weeks) periods. Results showed that increasing the amount of hull_less barley inclusion decreased feed intake and live-weight gain both in the starter and grower period (P<.0.01) but, did not significantly influence in finisher period. At the overall rearing period (0-49 days), increasing amount of hull-less barley in diet significantly decreased feed intake, weight gain, and feed conversion ratio (p<0.01). Increasing in hull-less barley inclusion rate, increased relative weight of gastrointestinal track, liver and ceca (P<0.01) but, did not influence the relative weight of abdominal fat and gizzard as well as the rate of mortality. Hull-less barley inclusion in diet decreased dietary AME and ileal and total tract digestibility of organic matter, crude protein, crude fat and starch in the starting period (p<0.01). The hull-less barley inclusion, however, did not significantly influence the nutrient digestibility (exclude crude fat) and AME in the finishing period. Enzyme supplementation did not show improvement in growth performance and nutrient digestibility in broilers. Increasing the amount of hull-less barley in the diet had the most negative effect on nutrient digestion of broilers at starter period and the reduction in broiler performance probably due to the depressed nutrient digestion. The magnitude of the reduction in digestibility and performance depends on the soluble NSPs concentration of hull-less barley containing diets.

Keywords: Broiler chicken, enzyme, hull-less barley, nutrient digestion, performance

INTRODUCTION

Barley is the preferred grain for cultivation in many areas in the world due to its resistance to drought and ability to mature in climates with a short growth season. Its use for poultry has however been limited by the considerable amounts of fiber contained in the grain which is considered to be undigested by all species of poultry.

Hull-less varieties of barley are successfully grown at a commercial scale in some countries, and when used with enzymes can be very suitable for use in poultry diets (Leeson and Summers, 2008) [21]. Hull-less barley differs from conventional barley in that the hulls firmly attached to the kernel and consequently is detached after thrashing, leading to a higher level of valuable nutrients and increased volume density(Thacker, 1999) [35]. The grain, however, also contains a highly viscous carbohydrate known as non-starch polysaccharides (NSPs), especially ß-glucans. The levels of ß-glucans in hull-less barley range from 40 to 70 g/kg, which are consistently higher than those (3 to 45 g/kg) in hulled barley (Baidoo and Liu, 1998) [5]. Classen et al. (1985) [12] found that high level of NSPs in hull-less barley can cause serious digestive problem in poultry. Choct et al. (1996) [8] showed that addition of extracted NSPs from cereal grains to broiler diets can decrease digestibility of protein, starch and fat; leading to a negative effect on broiler performance.

Although, the negative effects of NSPs content in barley and wheat on poultry performance are known, there is little published information on suitable dietary levels of hull-less barley in broiler diets. Further, the information regarding the effects of inclusion hull-less barley in broilers diet on nutrients digestibility are scare. Therefore, the objective of the current study was to investigate the effects of different levels of hull-less barley in diet on growth performance, pre-caecal and total digestibility of nutrients and metabolisable energy in broiler chickens at the starting and finishing periods. Another aim was to study the efficacy of using enzyme in experimental diets on the nutrient digestion and performance.

Material and methods

Diets

Diets were formulated to meet or exceed the nutritional recommendations of broiler chickens by NRC (1994) [22] (Table 1). Birds were fed a starter diet from 0 to 21d followed by grower and finisher diets from 22-35 and 36-49 d of age, respectively. A variety of hull-less barley grown in 2002 in Markazi province, Iran, was used in this study. Hull-less barley was added to basal diet with inclusion rates 0, 10, 20 and 30%. Each diet was supplemented with different levels (0, 300 and 600 g/ton) of Endofeed enzyme which its activity was as follows: β-glucanase (550 U/g) and xylanase (800 U/g).

Growth trial

Nine hundred and sixty one day old chicks from the Arbor Acres commercial strain broiler chickens were obtained from a local hatchery and used in a 4×3 Factorial arrangement with 4 levels of hull-less barley (0, 10, 20 and 30%) and 3 levels of Enzyme (0, 300 and 600 g/ton) . The broiler chickens with equal numbers of male and female were randomly distributed to 48 pens with 20 chickens housed per pen. As a result, a total of four replicates per treatment were used to measure production parameters and gut properties. The diets were given as a starter (0-21 days of age), as a grower (21-35 days of age) and as a finisher (35-49 days of age).

Table 1. Composition (g kg-1 DM) of the experimental diets[a]

	Starter (0 to 21d)				Grower(22 to 35d)				Finisher(35 to 49d)			
Ingredients	1	2	3	4	1	2	3	4	1	2	3	4
Maize	651.5	563	496	443	690.3	610.2	529.6	449	722.1	644.2	557	483
Soy bean meal	255.2	242.4	210.5	143.3	261.1	229	197.2	165.3	237.5	225	212.1	187
Hull-less barley		100	200	300		100	200	300		100	200	300
Fish meal	65	70	70	65	16.9	33.2	48.9	64.6				
Calcium phosphate	7	6	6.6	8.2	12.8	9.8	7	4.2	20.2	12.5	11.8	10.3
Oyster hell	8.5	8.5	8.5	9.3	9.8	9.2	8.8	8.3	12.5	9.9	10.1	11.2
Salt	2.1	1	0.9	0.8	2	2	2	2	2	2	1.5	1
DL- Met	2	2	2	1.8	2	2	1.5	1.5	0.5	1.5	1.5	1.5
Lysine	2.5	1.5	1	1	0.5	0.5					1	1
Vit.+Min premix	5	5	5	5	5	5	5	5	5	5	5	5
Calculated analysis												
[b]AMEn (kcal/kg)	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950
Crude protein	212	212	212	212	185	185	185	185	166	166	166	166
[c]S-NSPs	36.1	40.8	42.8	44	37	38.9	40.9	42.9	32.7	38.4	43	46
[d]I-NSPs	94	91.5	87.6	84	98	93.1	88.1	83.1	97.7	95.1	92.7	89.4
Measured Analysis												
Crude protein	219	222	208	207	195	190	188	192	163	161	157	156
[c]S-NSPs	35.8	41	43.1	44.3	36.6	39.2	40	43	32.3	37.6	42.6	45.8
[d]I-NSPs	96	87	89.5	81	96	88	99	88	100	105	101	92

[a]Each diet was supplemented with (0, 300 and 600g/ton),different levels of Endofeed enzyme, [a]Apparent metabolisable energy corrected for zero level of nitrogen. [c]Soluble non- starch polysaccharides, [d]Insoluble non- starch polysaccharides

The diets were fed as mash and chicks had free access to feed and water during the experimental period. The temperature was controlled and gradually reduced from 32ºC to 22ºC until day 21 and sustained until the end of experiment. Light was continuous during the whole experiment period over 24h. All chickens were weighted at the start (1-day old) and each week thereafter. Feed intake per pen (corrected for feed wastage) was registered at the same time and feed conversion ratio was calculated on pen weight basis. Dead chickens were weighted at the time of removal and included for calculating feed conversion ratio. At day 49, eight chickens were randomly selected (equal numbers of males and females) from each treatment group and killed by cervical dislocation. Immediately after death, the abdominal was opened and the total gastrointestinal tract exposed. Total gut tract was weighted and the gizzard, small intestine, caecum and liver were removed and weighted immediately. The pH of ileum content was measured by digital pH meter by inserting its glass electrode into ileum. Finally, the relative weight of carcass was measured by dividing the carcass weight by live body weight.

Digestion trial

Five hundred one day old male broiler chicks (Arbor Acres strain) were obtained from a local hatchery and raised on litter in an environmentally controlled room. All chickens were fed non-hull-less barley diets without any enzyme supplementation during the period they were raised on the litter (table. 2).
At days 15 and 38, two hundred and fifty two and one hundred and eighty chickens, respectively were randomly selected and used in two digestibility and AME trials (starter and finisher periods). The birds were randomly distributed to 36 battery cages (7 and 5 birds per cage for the first and second experiment, respectively) in a completely randomized design with a 4×3 factorial arrangement for hull-less barley inclusion rate (0, 10, 20 and 30%) and for enzyme addition (0, 300 and 600 g/ton) in iso-nitrogenous and iso-calorific experimental diets. Three replicates were given for each treatment. Chromic oxide (3 g/kg) was added to assay diets as an indigestible marker. Diets were offered ad libitum and water was available all the time. The experimental diets containing chromic oxide were given to chickens during 3-days adaptation period (days 15-17 and 38-40) and during the two collection periods. In the following 3 days (days 18-20 and 41-43), excreta were collected twice a day from all chicken in three pens per treatment. The trays placed under each pen in the cages were used for collection of excreta. Excreta collected per pen during the 3 days were pooled and represented one replicate. Contaminants such as feathers and scales were removed carefully before excreta were stored in closed container at -20°C immediately after collection to prevent microbial fermentation. On days 21 and 44, four and two chickens, respectively, from each replicate were killed by cervical dislocation. Immediately after death, the abdomen was opened and the intestinal tract exposed. Then, the total intestinal content was collected from 2 cm posterior to merckel’s diverticulum to 2 cm anterior to the ileal – caecal junction. Ileal digesta collected from the chickens in each pens were pooled, representing on replicate and then stored at -20°C in small plastic containers.
Chemical analysis
Dry mater content of hull-less barley, diets, excreta and ileal digesta were determined after drying at 70°C for 48 h. The samples were ground through 20 mesh screens for chemical analysis. The proximate feed and excreta analysis and starch content of them were performed according to AOAC (2000) [4]. The starch content of samples was analyzed by Colorimetric method described in AOAC (2000) [4]. The gross energy (GE) of diet, excreta and ileal samples were determined using an adiabatic bomb calorimeter model PARR 1261. Chromic oxide (Cr2O3) was determined using the method of Fenton and Fenton (1979) [14]. The total, soluble and insoluble NSP content in hull-less barley and experimental diets were analyzed according to the method of Choct (1995) [10].

Calculation and Statistical analysis

Apparent digestibility coefficient of nutrients in ileum/excreta and the AME values of experimental diets were calculated relative to the chromic oxide marker. All collected data from these experiments were examined by an analysis of variance (ANOVA) using the general linear model procedure (SAS, 2001) [30]. Means with significant F ratio were separated by the least significant difference test.

RESULTS

The chemical compositions of the hull-less barley used in the expernments have been presented in Table 2.

Table 2. Chemical Composition of the hull-less barley

Constituent	Hull-less barley
Dry matter	945
Gross energy(Kcal/ kg)	4206
[a]AMEn (Kcal/kg)	3230
Crud protein(N×6.25)	136
Crude fat (g/kg)	15
Crude fiber (g/kg)	16
Ash (g/kg)	20.1
Starch (g/kg)	654
[b]Sugars (g/kg)	45.7
Total non-starch polysaccharides (g/kg)	169
Soluble non- starch polysaccharides (g/kg)	46
Insoluble non- starch polysaccharides(g/kg)	123

[a]Apparent metabolisable energy corrected for zero level of nitrogen. [b]Sum of glucose, fructose, sucrose, rafinose, stachyose (low molecular weight sugars).

Growth performance

During the starting and growing periods, broilers showed decreased feed intake and live-weight gains as the amount of hull-less barley was increased ($p<0.01$). Weight gain of birds fed diets containing hull-less barley (300 g/kg) was significantly lower by on average 26.4% ,13.6%, 2.4% for starting, growing and finishing periods,compared with the control group(0g/kg), respectively(Table 3).
Feeding hull-less barley to birds significantly increased relative weight of GI tract, liver and ceca (g/100g of body weight). But the dressing percentage and relative weight of gizzard and abdominal fat were not influenced by the incereased hull-less barley in diets. Inclusion of different levels of Hull-less barley significantly reduced ileal pH ($p<0.01$). Mortalitiy was low in all group ranging from 3.75% (diet without hull-less barley) to 8.8% (diet with 30% hull-less barley), with no statistically significant difference between treatments. Enzyme supplementation had no effect on relative weight of organs, carcass yield, ileal pH and mortality (Table 4).

Digestibility and AME

At starter period, AME and apparent ileal and total tract digestibility of protein, fat, starch and organic matter decreased by increasing in dietary hull-less barley ($p<0.01$). No differences were observed in apparent ileal and total tract digestibility of nutrients and AME among the diets containing different levels of hull-less barley in the finishing period except for ileal digestibility of crude fat.
Enzyme supplementation had no significant effect on AME (kcal/kg) and apparent digestibility (%) of nutrients in ileum and total tract in the starting and finishing periods. However, numerically higher apparent nutrients digestibility were found with increasing levels of enzyme in diets at starting period. total tract digestibility of nutrients (except crude protein) was consistently lower than the ileal digestibility (Table5). The total tract digestibility of starch was highest in both starting and finishing periods.

Table3. Effect of hull-less barley (HB) and enzyme (E) supplementation on performance of starting, growing and finishing broilers.

			Starter (0 to 21d)			Grower (22 to 35d)			Finisher (36 to 49d)			Total (0-49 d)		
			Weight gain(g)	Feed intake(g)	FCR	Weight gain (g)	Feed intake(	FCR	Weight gain(g)	Feed intake(g)	FCR	Weight gain(g)	Feed intake(g)	FCR
Hull-less Barley (%)	0		570^{a}	872^{a}	1.54^{b}	675^{a}	1510^{a}	2.25^{a}	834.5	2260.1	2.73	2098^{a}	4570^{a}	2.20^{a}
	10		541^{b}	815^{b}	1.50^{c}	633^{a}	1397^{b}	2.22^{a}	851	2149	2.54	2021^{a}	4221^{a}	2.10^{b}
	20		505^{c}	793^{bc}	1.57^{ab}	652^{a}	1362^{b}	2.10^{b}	858	2079	2.43	2023^{a}	4189^{b}	2.15^{b}
	30		430^{d}	765^{c}	1.74^{a}	583^{b}	1219^{c}	2.10^{b}	814	2041	2.59	1776^{b}	3880^{c}	2.20^{a}
Enzyme (g/ton)	-	0	506	805	1.60	614	1353	2.21	818	2137	2.62	1993	4188	2.20
	-	300	507	808	1.59	659	1385	2.18	852	2151	2.55	2004	4241	2.10
	-	600	521	821	1.70	634	1378	2.10	849	2109	2.49	1925	4215	2.10
HB×E	0	0	563	864	1.55	635	1436	2.27	832	2291	2.75	1809	4468	2.24
	0	300	564	861	1.54	710	1532	2.16	849	2251	2.70	2105	3835	2.18
	0	600	582	892	1.55	680	1562	2.31	822	2239	2.74	2121	4679	2.20
	10	0	548	813	1.49	642	1468	2.31	793	2204	2.78	2005	4325	2.17
	10	300	5358	810	1.51	642	1371	2.14	862	2106	2.46	2051	4159	2.04
	10	600	540	823	1.53	615	1352	2.21	899	2137	2.38	2007	4178	2.08
	20	0	491	788	1.61	625	1306	2.10	822	2051	2.54	1945	4141	2.14
	20	300	498	780	1.57	692	1398	2.03	907	2140	2.46	2095	4251	2.03
	20	600	527	810	1.54	640	1381	2.17	852	2012	2.40	2030	4175	2.13
	30	0	422	756	1.80	554	1200	2.17	831	2004	2.42	1754	3811	2.18
	30	300	429	781	1.73	592	1239	2.10	790	2107	2.70	1763	3985	2.28
	30	600	439	757	1.69	603	1217	2.02	816	2047	2.36	1998	4569	2.06
P-Value														
HB			0.001	0.001	0.001	0.001	0.001	0.02	0.66	0.11	0.08	0.001	0.001	0.01
E			0.413	0.41	0.19	0.06	0.48	0.11	0.53	0.87	0.41	0.87	0.26	0.23
HB×E			0.72	0.43	0.12	0.15	0.08	0.59	0.7	0.98	0.39	0.82	0.93	0.39
^{e}SEM			24.2	34.1	0.15	50.8	78.4	0.14	93.2	236.9	0.27	144.2	277.6	0.11

$^{a-d}$Means within rows with different letters are significantly different ($P<0.05$), ^{e}Standard error of mean

Table 4. Effect of hull-less barley (HB) and enzyme (E) supplementation on carcass yield(%), relative weight of internal organs(%), mortality(%) and ileal pH of broiler.

Variables	Total gut	Gizzard	Ceca	Liver	Abdominal fat	Carcass yield	Mortality	Ileal pH
Hull-less barley (%)								
0	11.62 [b]	3.3	0.65 [c]	2.58 [b]	1.97	63.73	3.75	6.71 [a]
10	11.83 [b]	3.4	0.68 [bc]	2.5 [b]	1.78	63.32	8.33	6.43 [b]
20	12.58 [ab]	3.5	0.78 [ab]	2.60 [b]	1.80	62.36	6.60	6.23 [b]
30	12.84 [a]	3.5	0.85 [a]	2.89 [a]	2.07	60.57	8.80	5.64 [c]
Enzyme(g/ton)								
0	121.58	3.5	0.67	2.63	1.98	61.30	6.9	6.20
300	11.92	3.2	0.79	2.55	2.03	63	7.8	6.30
600	12.16	3.4	0.80	2.74	1.90	63.30	5.9	6.32
P-Value								
HB	0.031	0.72	0.002	0.032	0.58	0.081	0.20	0.001
E	0.25	0.17	0.23	0.26	0.81	0.17	0.98	0.41
HB×E	0.95	0.51	0.51	0.40	0.27	0.32	0.73	0.99
[d]SEM	1.11	0.46	0.21	0.33	0.53	3.12	6.37	0.30

[a-c]Means within rows with different letters are significantly different (P<0.05)
[d]Standard error of mean

DISCUSSION

The higher protein content in hull-less barley compared to corn grain and its considerable AMEn make it a potentially good ingredient in diets for poultry. Classen and Bedford (1999) [11] reported that the hull-less barley has a higher AME and protein content than hulled barley because of diluting effect of the fibrous hulls. However, since the high content of NSP probably decrease nutrient digestibility and performance due to the lack of appropriate enzyme in the digestive tract of chickens, some concern has been expressed in relation to the inclusion levels of hull-less barley in broiler diets. The total and soluble NSP content of the hull-less barley cultivar used in present study were 169 and 46 g/kg DM, respectively. In different hull-less barley varieties grown across the world, the NSP content was shown to be an average 13.45-15.1 percent (Yin et. al., 2001) [37] which is less than the value found in the present study. The results obtained in the present study indicated that the inclusion of hull-less barley in broiler diets decreased weight gain and feed intake in starting and growing periods.

Table 5. AME (kcal/kg DM) and and ileal and total tract digestibility (%) of nutrient in broiler fed on diet containing different levels of hull-less barley(HB) and enzyme(E) at different age.

	Variables										
	Hull-less Barley(% diet)				Enzyme(g/ton)			^{e}SEM	P-Value		
	0	10	20	30	0	300	600		HB	E	HB×E
Ileum(d 21)											
Protein	77.9^{a}	76.01^{b}	73.5^{c}	71.7^{d}	72.2	75	74.2	1.09	0.001	0.1	0.12
Fat	88.0^{a}	86.6^{a}	86.3^{a}	78.4^{b}	83.4	85.4	85.6	2.7	0.001	0.12	0.8
^{f}OM	74.7^{a}	73.2^{b}	71.3^{c}	70.5^{c}	71.8	72.5	73	0.87	0.001	0.06	0.2
^{g}AME	3131^{a}	3061^{b}	3037^{bc}	3017^{c}	3064	3049	3074	32.4	0.001	0.12	0.12
Total tract(18-20 d)											
Protein	70.1^{a}	66^{b}	60.4^{c}	60.8^{c}	62.6	65.1	65.3	0.61	0.001	0.21	0.4
Fat	92.8^{a}	89.4^{b}	88.8^{b}	78.4^{c}	86.01	87.5	88.5	3.2	0.001	0.18	0.11
^{f}OM	80.8^{a}	78.4^{a}	74.7^{b}	73.9^{b}	76.01	77.2	77.6	4.1	0.001	0.30	0.36
Starch	97.7^{a}	96.7^{b}	96.6^{b}	94.6^{c}	96.1	96.04	96.5	2.5	0.001	0.29	0.88
^{g}AME	3299^{a}	3196^{a}	3070^{b}	3069^{b}	3137	3160	3179	124.2	0.001	0.71	0.62
Ileum(d 44)											
Protein	78	77.4	75.3	76.5	76.1	77.3	77	3.13	0.30	0.6	0.9
Fat	86.2a	86.3a	82.7b	83.4b	84.5	84.4	85.1	3.1	.04	0.84	0.38
^{f}OM	81.2	80.4	81.6	81.6	81.5	80.7	81.4	2.2	0.60	0.61	0.2
^{g}AME	3423	3365	3298	3312	3423	3325	3352	125.1	0.07	0.52	0.16
Total tract *(41-43 d)*											
Protein	70.6	70.1	70.2	70.4	69.9	69.8	71.2	4.5	0.99	0.70	0.12
Fat	89	88.5	87.9	87.2	79.6^{b}	82.9^{b}	84.8^{a}	2.9	0.30	0.08	0.47
^{f}OM	84.6	85.2	82.1	82.1	82.6	84	84.5	2.9	0.22	0.73	0.16
Starch	97.7	97.8	97.5	97.1	97.2	97.6	97.8	0.62	0.12	0.06	0.052
^{g}AME	3518.1	3574	3513	3453	3504	3516	3525	119.3	0.23	0.20	0.2

$^{a-d}$Means within rows with different letters are significantly different (P<0.05)
^{e}Standard error of mean, ^{f}OM: Organic Mater, ^{g}AME: Apparent metabolisable energy.

The nutrients were digested less efficiently in chickens fed on diets containing hull-less barley (P<0.01) which confirm the observed response on performance parameters in the chickens. This is in accordance with the finding of (Classen et.al., 1985) [21] that showed that the hull-less barley cultivars significantly reduced the excreta dry matter, feed intake, body weight and feed conversion. Almirall et al. (1995) [1] observed a decrease in the apparent digestibility of crude fat in barley substitute diet fed to broiler. Salih et. al. (1991) [29] observed that the broiler diets containing high amounts of hull-less barley (60 and 70 % in starter and finisher, respectively) severely depressed productive performance and fat digestibility. But dietary supplementation with different levels of enzyme improved performance and fat daigetibility. An important purpose of the present experiment was to examine if the supplementation of different enzyme levels could improve AME, nutrient digestibility and performance of broiler chickens fed diets containing different level of hull-less barley at different rearing periods. From the results obtained, it can be concluded that improvements in performance were seen at starting period but they were not significance.

The lower digestibility of nutrients in the hull-less barley containing diets might be due to higher level of soluble NSP especially B-glucans. Baidoo and Liu (1998)[5] reported that the B- glucan content of hull-less barley is approximately 4-7 %. Soluble NSP dissolves in the digestive tract and interacts to form high molecular weight viscous aggregates (Bedford and Classon, 1992; Annison, 1993) [3, 6]. Thus, they have a negative effect on the performance of birds by increasing digesta viscosity which results in the reduced gastro-intestinal passage rate, diffusion of digestive enzymes, digestibility and absorption of nutrients(Bedford and Classon(1992) [6], and promotes the secretion of endogenous enzymes(Choct, and Annison, 1992) [9] and stimulates bacteria proliferation particularly in the small intestine(Hock et.al.,1997) [16]. Tentens et al.(1996) [34] indicated that the dietary fibre accelerated the turn over rate of mocuse cell, decreased digestive enzyme secretion, decreased the re-absorption of endogenous amino acids, increased endogenous fecal nitrogen excretion, hence decreased digestibility. Furthermore, NSPs could reduce enzyme activity such as amylase and lipase by affecting on pancreas and small intestine(Almiral et. al., 1995) [1]. Choct et al.(1996) [8] fed the high NSPs diet to broiles that resulted in low nutrient digestion in the ileum. Soluble NSP will increase digesta retention time and thicken the unstirred water layer in the GI tract due to its viscosity (1986) [20]. Sharifi et al. (2007) [31] indicated a decrease in the heights and widths of the intestinal villus of broilers fed diets containing high concentration of soluble NSPs. Therefore, excessive reduction in the absorptive area in digestive tract could be one of the factors for poor nutrients digestion found in broiler chickens fed on diet containing high levels of hull-less barley. In the present study starch was digested to a very high extent in all groups, however, enzyme supplementation did not significantly increase the apparent starch digestibility in both growing and finishing periods. Starch is the major energy source in cereal grains and its digestibility contributes to AME value of experimental diets (Fig. 1 and 2). According to Rogel et. al. (1987) [27] a close correlation exists between starch digestibility and AME of wheat based diet. Riesenfeld et. al. (1980) [26] reported that the main part of starch content in the diet is digested in the duodenum and that the digestion of starch is normally complete in the jejunum. The jejunum was reported to be the major site of lipid absorption in chickens. Bile salts are required for fat emulsification of particularly saturated fats(Leeson and Summers, 2008) [21] and since bile salt are produced in limiting amounts during the first weeks of life in chickens. Excessive deconjugation of bile salts by intestinal bacteria could be one of the factors responsible for poor fat digestion in the present study. Deconjugation of bile salts was reported in broiler chickens fed with diets with high inclusion level of barley, rye and wheat contain varying level of soluble NSP(Choct and Annison, 1992; Friesen et, al. 1992; Choct et. al., 1996) [8, 9 and 15].

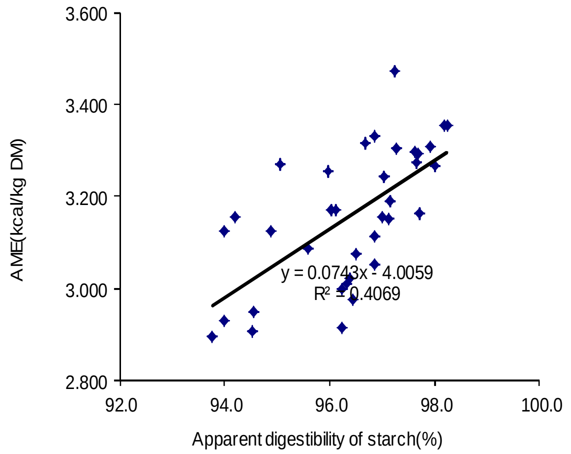

Fig. 1. The correllation between dietary AME(kcal/kg DM) and the apparent digestibility of starch(%) measured in excreta from broler chickens 21 days of age

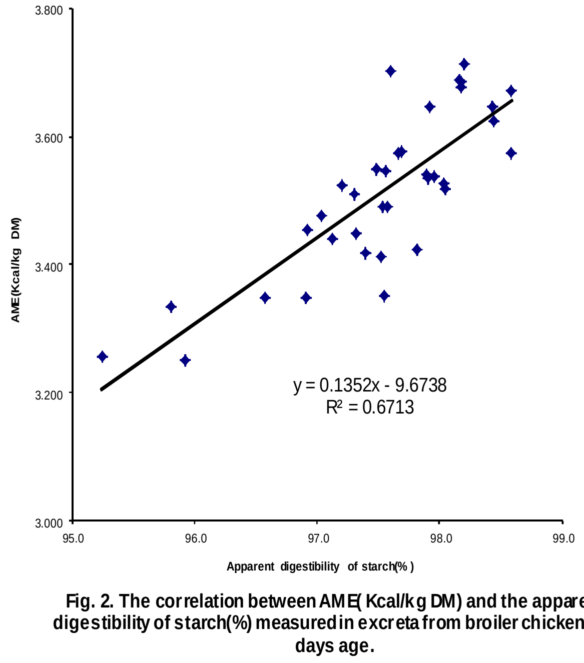

Fig. 2. The correlation between AME(Kcal/kg DM) and the apparent digestibility of starch(%) measured in excreta from broiler chickens 45 days age.

In this study, protein digestibility was decreased by increasing the level of hull-less barley in diet. Total tract digestibility of protein was lower than of ileal digestibility. This result is in agreement with the finding of Smits and Annison(1996) [33] who demonstrated a significant reduction of apparent nitrogen digestibility after feeding higher NSP to the birds. Pervious study has demonstrated that endogenous protein losses are significantly increased by wheat NSPs (Angkanaporn et.al., 1994) [2]. Unabsorbed nitrogen components are known to be fermented by the micro flora in the ceca to a certain extent (Parsons, 1986) [25]. In poultry, feces and urine are excreted together; these could be factors responsible for differences between ileal and excreta protein digestibility. Doeshate et al. (1993) [13] suggested that the determination of apparent protein digestibility in the ileum can be the most reliable method in poultry. The effectiveness of enzyme on protein digestibility reported in the literature are highly variable with some studies reporting increase in nitrogen digestibility (Almirall,1995) [1], while, Jenson et. al. (1998) [19] indicated no response of enzyme supplementation both in the hull- less and hulled barley diets.

In the present study the relative weight of GI tract, liver and ceca were influenced by hull-less barley inclusion rate. The results agreed with the results reported by Bedford and Classon(1992) [6] that high B-glucan barley strains inclusion increased the relative weight of duodenum, jejunum and ileum, and by Yu et. al. (2002) [38] that dehulled barley fed to broiler increased GI tract weight. Iji et al.(2001a; 2001b) [17, 18] and Lesson and Zubair (1997) [22] observed an increase in the weight of liver in chickens fed a high protein diet. In the barley based diet, damage to the small intestine mucose may be caused indirectly by the viscose characteristics of NSPs. Volatile fatty acids and polyamines produced by the gut microflora have stimulatory effects on the proliferation rate and secretary activity of intestinal mucosa (Iji et. al. 2001a) [17]. The high amount of hull-less barley inclusion rate in this trial increased microbial growth in the ceca (Sharifi et. al., 2007)[32] and consequently increased VFA concentration in the ceca and relative GI tract weight. These changes could be causes for increasing in relative weight of GI tract in the present study. The enlargement of ceca indicates that the fermentation activity in the ceca has increased. The increased fermentation activity was confirmed by the reduction of ileal pH due to increasing hull-less barley inclusion rate to diets in this study. The enlargement of liver could be due to the increased activity of it for bile acid secretion. Increasing in retention time of digesta caused the population of *Streptococcus faecium* grow rapidly in the small intestine (Salih et.al., 1991) [29]. These bacteria deconjugate bile acids and as a result liver increases its activity to compensate lost bile acids.

Enzyme inclusion did not significantly influence weight gain, feed intake and feed conversion in broiler during starting, growing and finishing periods. This result was different from some other research that B-glucanase supplementation barley diet improved broiler performance during growing periods (Rotter et. al., 1990)[28].

Results from this study did not show any significant effects of hull-less barley inclusion levels on ileal (except fat) and excreta digestibility of nutrients in the finishing period. It could be suggested that the digestive system is relatively well developed in finishing broilers with less impact from high soluble NSPs feedstuff. It is well known that the capacity of young birds to digest nutrients increases with age (Nir, et.al., 1993)[24]. In addition, the anti nutritive effects of water soluble NSP are more pronounced in young birds than in older brids(Veldmanet.al., 1994) [36]. Classen and Bedford (1999) [11] reported that the major negative effect of feeding high ß-glucan barley is during the first four weeks of life for broiler chickens. Older birds appear to be capable of more readily transporting viscous material in the gastrointestinal tract and therefore nutrients digestions were not adversely affected.

Conclusion

The results obtained in this experiment suggest that there is strong relation between inclusion rate of hull-less barley in diet and the reduction of ileal and total tract digestibility coefficients of nutrients in broiler chickens at starting period. The reduction in nutrients digestibility causes the depression in broiler performance. In conclusion, the negative effect of high level of hull-less barley in broiler diets are primary due to high content of soluble non-starch in barley which depressed AME and apparent digestibility of dietary nutrients. The magnitude of the reduction in digestibility and performance depends on the concentration of soluble non-starch polysaccharides of hull-less barley containing diets. Nutrients digestibility coefficients and therefore, performance are improved by aging in broiler chickens.

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