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Influence of Enzyme Supplementation of Maize, Wheat and Barley-based Diets on the Performance of Broiler Chickens

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Abstract: The use of enzymes has been common in many industries for many years. More recently, the animal feed industry began to incorporate specific enzymes in the animal and poultry feed. The main goals of enzyme supplementation of poultry diets have predominantly been related to the hydrolysis of fiber or NSP fraction in cereal grains. The purpose of the present study was to investigate the effect of exogenous enzyme supplementation of maize, wheat and barley-based diets on broiler performance. A total of 720 one day-old broiler chicks (Arian breed) were allotted at random in equal numbers in floor pens (3 pen/treatment) and fed with 8 different ingredient diets. Broiler diets were prepared based on: a standard maize based diet (M); maize plus enzyme (ME); barley plus enzyme (BE); wheat plus enzyme (WE); maize-barley plus enzyme (MBE); maize-wheat plus enzyme (MWE); wheat-barley plus enzyme (WBE) and maize-wheat-barley plus enzyme (MWBE). From day 7 onwards and repeated weekly body weight gain, feed intake, feed conversion, mortality was determined. At the end of rearing period six chickens per treatment were slaughtered and carcass yield, abdominal fat pad content, intestine's weight and size changes were measured. The result gives an impression that no significant differences were found in terms of live weight, feed intake, feed efficiency and chick's survivability between enzymes treated and control diets. Dietary enzymes had no effect on gizzard and liver weight, carcass yield and abdominal fat pad contents. Enzyme supplementation, however significantly influence the weight but not the size of intestine. It has been shown that adding of enzyme to the feeds based on cereal grains with higher fiber contents improve the performance of broiler chicks to the levels at least as those obtained with maize based diets. The obtained results at the present study indicate the anti-nutritive effects of SNP on the performance of broilers were overcome by adding of enzymes.

Key words: Exogenous enzyme, diets, broiler performance

INTRODUCTION

The feed and animal production industry use enzymes as a means to alter the nutrient value of the ingredients in order to obtain the optimal benefit from the specific feed enzyme. In broiler diet most of the feed ingredients with the plant origin contain non-digested part such as cellulose, exylose, arabinose and also some anti-nutritive factors which negatively affect the digestibility and absorption of nutrients and finally reducing broiler performance (Alam *et al*., 2003). In addition of cereal grains, these anti-nutritive factors are also present in the oil seeds such as soybean, canola and cotton seed. In several reports it has been shown that pentosans affect the metabolizable energy value of wheat (Choct and Annison, 1990; Annison and Choct, 1991). Pentosans are contained arabinoxylans, which are linked to other cell wall components and able to absorb up to 10 times their own weight of water and forming highly viscous solution (Alam *et al*., 2003). It was demonstrated that the viscosity of the arabinoxylans exerts their anti-nutritive activity. This anti-nutritive effect is maintained by depressed nutrient utilization accompanied by a poor growth in broiler rearing (Choct and Annison, 1992b). These compounds are indigestible because of the inability of monogastrics to secret specific enzymes (Ravindran *et al*., 1999).

The soluble or insoluble forms of Non Starch Polysaccharides (NSP) and protein inhibitors are two main groups of anti-nutritive factors which are present in cereal grains and also the feed meals which have not been well processed (Hong and Adeola, 2002). It has been shown that canola meals contains 13-16% NSP like arabinos present in endosperm of cereal grains such as wheat and β-glucans present in barley (Samarasinghe *et al*., 2000). Insoluble NSP like cellulose are fermented in minute

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amount at the end of the digestive tract of birds and produce volatile fatty acids (Campbell and Bedford, 1992). Also pectens are anti-nutritive compounds from the groups of glycoprotein that are present in plant tissue principally in cereals grain especially in legumes grain (Spring *et al*., 1996). It has been reported that the tripsin inhibitors are present in legumes especially in raw soybean and also in soybean meal which are not well processed. These inhibitors inhibits the activity of tripsin enzyme where result in incomplete digestion and absorption of proteins in digestive tract. Because tripsin not only hydrolyses some of the proteins in soybean but also activate some endo-peptidases such as chimotrypsin, elastases and carboxy-peptidases. Tripsin inhibitors activate a negative feed back mechanism in the pancreas, which in turn reduce the tripsin concentration in the duodenum which causes the activity of pancreas to increase (Femandez, *et al*., 2000). Supplementation of digestive enzyme to poultry diet containing cereal grain and/or feed meals which are not processed well can increase the quality of the feed. Adding enzymes to bird diet can break down anti-nutritive factors and then eliminate their negative effects (Douglas *et al*., 2000). It has been reported that a considerable part of maize starch passes to the lower part of the digestive tract and fermented without being digested. This phenomenon reduces the energy production ability of the feed. Adding enzyme to a maize-soybean diet improves feed digestions at the upper parts of the digestive tract which in turn increases the efficiency of energy and improves animal performances (Zanella *et al*., 1999). It has been reported that digestibility of soybean meal can be increased by enzyme supplementation (Douglas *et al*., 2000). The purpose of the present study was to investigate the effect of exogenous enzyme supplementation of maize, wheat and barley-based diets on broiler performance.

MATERIALS AND METHODS

Chickens, housing and management: The experiment was conducted at poultry research farm of Mazandaran University at Mazandaran province in north of Iran on October 10th to November 23th 2004. A total of 720 one day-old broiler chicks (Arian breed) were allotted at random in equal numbers in floor pens (3 pen/treatment) and fed with 8 different ingredient diets. Broiler diets were prepared based on: a standard maize based diet (M); maize based diet plus enzyme (ME); barley based diet plus enzyme (BE); wheat based diet plus enzyme (WE); maize-barley based diet plus enzyme (MBE); maize-wheat based diet plus enzyme (MWE); wheat-barley based diet plus enzyme (WBE) and maize-wheat-barley based diet plus enzyme (MWBE). The specific or multi-enzyme complex kindly was provided by Aveve Company from Belgium. Wood shavings were used as litter and a nearly continuous lighting regimen provided 23 h of light per 24 h throughout the rearing period. Water and food were available *ad libitum*. All chicks were vaccinated against infectious bronchitis, Gumboro and Newcastle disease. Temperature was set at 30°C during the first week and gradually reduced by 2°C per week down to 20°C. The ingredients used in the diet and the calculated nutrient analyses are shown in Table 1-3.

Measurements and statistical analysis: From day 7 onwards and repeated weekly body weight gain, feed intake, feed conversion, mortality was determined. At the end of rearing period six chickens per treatment were slaughtered and carcass yield, abdominal fat pad content, intestine's weight and size changes were measured. The performance data were analysed by analysis of variance using the General Linear Model procedure (SAS, 1986) with dietary treatments as fix effects. If a significance effect of variables was calculated, means were contrasted by Duncan's multiple range test.

RESULTS AND DISCUSSION

There was a significant differences ($p<0.05$) in average body (Table 4) weight in between different treatment groups at starter, grower and finisher rearing periods. At starter periods the ME treatment group showed the lowest body weight but at finisher periods the BE and WE showed the lowest and highest body weight, respectively. It has been reported that maize compared to other grains has a low amount of soluble NSP, therefore it is less affected by enzyme addition (Sohail *et al*., 2003). In the other hand, it was shown that the enzyme response is dependent to the age of birds and the highest response can be achieved at the first 3 weeks of age (Selvendran *et al*., 1987). There was a significant differences ($p<0.05$) between dietary treatments in feed consumption at both starter and finisher groups (Table 4). In both starter and finisher periods the lowest feed consumption was found the BE dietary treatment. In finisher period the lowest feed consumption was found for MBE group. It has been reported that the lower feed consumption in broiler chickens that were fed with enzyme supplemented dietary can be because of the increasing metabolizable energy as adding of enzyme to the feed (Annison, 1992). It has been stated that the anti-nutritive effect of insoluble NSP to apparent metabolizable energy is due to the inhibition of digestion of starch, protein and fat in the intestine because the soluble NSP increase viscosity of digestible materials reduce the

Table 1: Percent of ingredients and calculated nutrient analyses in broiler starter diets (1-2 weeks of age)

	Different diets							
Feed ingredients	M	ME	BE	WE	MBE	MWE	WBE	MWBE
Maize	59.12	59.12	-	-	40.00	40.00	18.00	20.00
Wheat	-	-	-	62.72	-	20.30	42.53	20.00
Barley	-	-	55.84	-	18.06	-	-	19.16
Soybean meal	36.18	36.18	33.56	31.30	35.13	34.52	31.87	33.65
Fat	1.14	1.14	2.00	2.52	3.03	1.58	3.96	3.59
Limestone	1.26	1.26	1.31	1.25	1.27	1.26	1.27	1.27
Calcium phosphate	1.40	1.40	1.34	1.40	1.38	1.40	1.38	1.38
Enzyme*	-	+	+	+	+	+	+	+
Mineral premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL- methionine	0.10	0.10	0.16	0.20	0.12	0.13	0.18	0.15
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis								
Crude protein (%)	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
ME, Kcal/kg	2900.00	2900.00	2900.00	2900.00	2900.00	2900.00	2900.00	2900.00
Calcium (%)	0.90	0.90	0.91	0.91	0.91	0.91	0.90	0.90
A.Phosphorous (%)	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
M+C (%)	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Lysine (%)	1.12	1.12	1.13	1.03	1.13	1.09	1.06	1.09
Crude fiber (%)	3.83	3.83	5.14	4.06	4.25	3.91	4.41	4.35

M = Maize, ME = Maize + Enzyme, BE = Barley + Enzyme, WE = Wheat + Enzyme, MBE = Maize + Barley + Enzyme, MWE = Maize + Wheat + Enzyme, WBE = Wheat + Barley + Enzyme, MWBE = Maize + Wheat + Barley + Enzyme, A = Available, * Enzyme added at the recommended level of manufacture

Table 2: Percent of ingredients and calculated nutrient analyses in broiler grower diets (2-4 weeks of age)

	Different diets							
Feed ingredients	M	ME	BE	WE	MBE	MWE	WBE	MWBE
Maize	64.25	64.25	-	-	40.00	40.00	-	21.00
Wheat	-	-	-	68.41	-	25.74	30.00	21.00
Barley	-	-	60.68	-	22.90	-	34.00	22.16
Soybean meal	30.68	30.68	27.84	24.88	29.61	28.59	26.63	27.93
Fat	1.68	1.68	8.05	3.14	4.08	2.24	5.90	4.47
Limestone	1.20	1.20	1.25	2.52	3.03	1.58	3.96	3.59
Calcium phosphate	1.26	1.26	1.31	1.19	1.22	1.19	1.22	1.21
Enzyme	-	+	+	+	+	+	+	+
Mineral premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL- methionine	0.07	0.07	0.13	0.17	0.09	0.11	0.15	0.12
L-Lysine	-	-	-	0.09	-	-	0.01	-
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis								
Crude protein (%)	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
ME, Kcal/kg	3000.00	3000.00	3000.00	3000.00	3000.00	3000.00	3000.00	3000.00
Calcium (%)	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
A. Phosphorous (%)	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
M+C (%)	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Lysine (%)	0.99	0.99	0.99	0.95	0.99	0.95	0.95	0.96
Crude fiber (%)	3.56	3.56	4.98	3.79	4.09	3.65	4.46	4.16

M = Maize, ME = Maize + Enzyme, BE = Barley + Enzyme, WE = Wheat + Enzyme, MBE = Maize + Barley + Enzyme, MWE = Maize + Wheat + Enzyme, WBE = Wheat + Barley + Enzyme, MWBE = Maize + Wheat + Barley + Enzyme, A = Available, * Enzyme added at the recommended level of manufacture

contact between digestive enzyme and their substrate (Choct and Annison, 1992a). Therefore the lower feed consumption in diets containing enzyme can be because of the improvement in metabolizable energy of the feed. A significant difference ($p<0.05$) in feed conversion between different dietary groups was only found at starter period. The ME and WBE showed the lowest feed conversion ratio (Table 4). It has been reported that adding β-glucanase to the barley containing diet can improve broiler performance at three first weeks of age (Rogel *et al.*, 1987). In generally, the broiler performance was improved in all WE, MBE, MWE, WBE and MWBE experimental groups. The lowest survivability rate was found in WE and MWBE groups respectively.

Table 3: Percent of ingredients and calculated nutrient analyses in broiler finisher diets (4-6 weeks of age)

	Different diets							
Feed ingredients	M	ME	BE	WE	MBE	MWE	WBE	MWBE
Maize	68.52	69.84	-	-	45.00	46.20	-	26.00
Wheat	-	-	-	65.20	-	25.23	22.64	18.00
Barley	-	-	65.41	-	23.63	-	45.37	25.00
Soybean meal	25.92	25.92	23.05	24.52	24.75	22.74	21.30	22.40
Fat	0.19	0.19	8.07	6.77	3.10	2.23	7.16	4.97
Limestone	1.11	0.98	1.11	0.97	1.03	0.98	1.07	1.03
Calcium phosphate	1.99	1.61	1.39	1.51	1.53	1.61	1.45	1.52
Enzyme*	-	+	+	+	+	+	+	+
Mineral premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.27	0.27	0.30	0.30	0.27	0.28
DL- methionine	0.14	0.14	0.20	0.20	0.16	0.16	0.19	0.18
L-Lysine	-	-	-	0.04	-	-	0.05	0.11
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis								
Crude protein (%)	18.80	18.80	18.80	18.80	18.80	18.80	18.80	18.80
ME, Kcal/kg	3050.00	3050.00	3050.00	3050.00	3050.00	3050.00	3050.00	3050.00
Calcium (%)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
A. Phosphorous (%)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
M + C (%)	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Lysine (%)	0.99	0.99	0.99	0.98	0.98	0.98	0.98	1.03
Crude fiber (%)	3.01	3.01	4.19	4.13	2.17	2.51	3.66	2.58

M = Maize, ME = Maize + Enzyme, BE = Barley + Enzyme, WE = Wheat + Enzyme, MBE = Maize + Barley + Enzyme, MWE = Maize + Wheat + Enzyme, WBE = Wheat + Barley + Enzyme, MWBE = Maize + Wheat + Barley + Enzyme, A = Available, *Enzyme added at the recommended level of manufacture

Table 4: Growth performance in broiler chickens fed with different ingredient diets at different rearing periods

	BW (g)			FC (g)			FCR		
T	S	G	F	S	G	F	S	G	F
M	270±11^{a}	903±56^{a}	1729±99^{ab}	384±39^{a}	1432±66^{a}	3527±375^{a}	1.4±0.8^{a}	1.58±0.8^{b}	2.04±0.1
ME	253±3^{bc}	880±80^{a}	1706±64^{abc}	334±22^{bc}	1374±55^{ab}	3394±204^{ab}	1.2±0.1^{b}	1.56±0.9^{b}	1.99±0.6
BE	254±5^{bc}	704±59^{b}	1520±42^{c}	325±13^{c}	1232±66^{d}	2888±71^{b}	1.3±0.3^{ab}	1.75±0.8^{a}	1.90±0.8
WE	258±8^{abc}	790±77^{ab}	1809±99^{a}	340±26^{abc}	1327±76^{abcd}	3382±99^{ab}	1.3±0.6^{ab}	1.68±0.8^{ab}	1.87±0.2
MBE	254±5^{bc}	805±76^{ab}	1630±20^{abc}	326±19^{c}	1322±85^{abcd}	3162±81^{ab}	1.3±0.6^{ab}	1.64±0.5^{ab}	1.94±0.3
MWE	270±4^{a}	836±38^{ab}	1612±89^{abc}	384±20^{a}	1364±31^{abc}	3288±195^{ab}	1.4±0.5^{a}	1.62±0.4^{ab}	2.04±0.1
WBE	259±8^{abc}	786±62^{ab}	1581±96^{bc}	343±26^{abc}	1272±34^{bcd}	2942±258^{ab}	1.2±0.1^{b}	1.62±0.1^{ab}	1.86±0.7
MWBE	267±6^{ab}	703±62^{b}	1623±151^{abc}	378±19^{ab}	1246±74^{cd}	3182±498^{ab}	1.4±0.4^{a}	1.77±0.8^{a}	1.96±0.1

T = Treatment, BW = Body weight, FC = Feed conversion, FCR = Feed conversion rate, S = Starter, G = Grower, F = Finisher, M = Maize, ME = Miaze + Enzyme, BE = Barley + Enzyme, WE = Wheat + Enzyme, MBE = Maize + Barley + Enzyme, MWE = Maize + Wheat + Enzyme, WBE = Wheat + Barley + Enzyme, MWBE = Maize + Wheat + Barley + Enzyme. $^{a, b, c, d}$Means within a column with no common superscript differ significantly ($p<0.05$)

Table 5: Mean carcass yield (percentage of live weight) in broiler chickens fed with different ingredient diets at 42 days of age

T	Carcass	Breast	Leg	Liver	Pancreas	Gizzard	Fat pad
M	90.4±1^{ab}	19.1±2.2	22.7±1.9	4.0±0.60	0.53±0.2	3.4±0.7	1.05±0.1
ME	90.0±0.7^{ab}	18.9±0.8	22.6±1.6	3.6±0.83	0.50±0.1	3.6±0.9	1.18±0.1
BE	8.07±0.5^{b}	18.5±0.5	22.8±0.9	3.5±0.25	0.59±0.2	5.0±0.37	1.00±0.12
WE	89.7±2^{ab}	18.9±0.4	22.9±0.6	3.4±0.17	0.52±0.1	3.8±0.41	1.11±0.1
MBE	91.3±3^{a}	19.3±1.7	21.5±0.6	3.4±0.24	0.63±0.2	4.4±1.3	1.00±0.14
MWE	90.0±2.5^{ab}	17.7±2.7	21.8±1.9	3.8±0.80	0.54±0.3	3.6±0.98	1.06±0.1
WBE	89.7±3^{ab}	19.2±2.3	23.0±0.5	3.7±0.55	0.60±0.2	4.3±0.28	1.20±0.2
MWBE	89.4±0.6^{ab}	77.4±1.4	21.5±1.8	3.8±0.50	0.65±0.1	4.9±0.64	1.10±0.11

T = Treatment, M = Maize, ME = Maize + Enzyme, BE = Barley + Enzyme, WE = Wheat + Enzyme, MBE = Maize + Barley + Enzyme, MWE = Maize + Wheat + Enzyme, WBE = Wheat + Barley + Enzyme, MWBE = Maize + Wheat + Barley + Enzyme. $^{a, b}$ Means within a column with no common superscript differ significantly ($p<0.05$)

The mean carcase yield showed significant difference ($p<0.05$) between dietary treatments but the weight of breast, leg, liver, pancreas, gizzard and abdominal fat were not affected by the different diets (Table 5). It has been shown that the breast and leg weight increased in broiler chickens fed by enzyme supplemented of wheat and barley based diet (Isaksson *et al.*, 1982). The results of intestine characteristics is shown in (Table 6). No significant differences were found on weight and length of the duodenum, jejunum and ileum between different experimental groups. It has been reported that the weight of digestive system reduced up to 20% by adding enzyme

Table 6: Mean intestine weight (percentage of live weight) and intestine length (centimeters) in broiler chickens fed with different ingredient diets at 42 days of age

T	Duodenum (Weight)	Jejunum (Weight)	Ileum (Weight)	Duodenum (Length)	Jejunum (Length)	Ileum (Length)
M	0.5±0.1[ab]	1.4±0.4[b]	1.40±0.4[b]	20.60±0.6	109.70±6	92.30±5.1
ME	0.4±0.1[ab]	2.0±0.8[ab]	2.00±0.7[ab]	20.00±2	107.30±21	94.70±10
BE	0.6±0.1[ab]	1.5±0.1[ab]	1.60±0.2[ab]	19.70±1.5	98.70±4.5	84.70±5
WE	0.3±0.1[b]	1.5±0.1[ab]	2.07±0.5[ab]	18.30±2	96.70±5.1	84.30±4
MBE	0.6±0.2[ab]	1.5±0.1[ab]	1.56±0.3[ab]	19.00±0.1	96.30±8	81.30±1.2
MWE	0.4±0.2[ab]	2.0±0.3[ab]	1.94±0.4[ab]	19.00±2.6	103.70±8	90.00±3.6
WBE	0.5±0.3[ab]	1.6±0.1[ab]	1.66±0.4[ab]	19.30±2	102.60±8	86.70±12
MWBE	0.7±0.1[a]	2.6±0.2[a]	2.62±0.2[a]	21.30±2.8	104.00±9	86.70±8.3

T = Treatment, M = Maize, ME = Maize + Enzyme, BE = Barley + Enzyme, WE = Wheat + Enzyme, MBE = Maize + Barley + Enzyme, MWE = Maize + Wheat + Enzyme, WBE = Wheat + Barley + Enzyme, MWBE = Maize + Wheat + Barley + Enzyme. [a, b] Means within a column with no common superscript differ significantly ($p<0.05$)

(Petterson and Aman, 1989). Although, the diets used to feed broiler chickens are mainly based on maize and soybean because of their low fiber, high digestibility and low anti-nutritive factors compare to other cereals, but using enzymes made it possible to use cereals with high fiber content such as wheat and barley in broiler feeding program (Brenes *et al*., 1993; Yin *et al*., 2000).

As shown in the present study adding enzymes to the diets based on cereals can improve broiler performance compared to the control maize based diet. The obtained results indicate that adding enzyme on a cereal based diet overcome the anti-nutritive effects of the cereals on broiler performance. It can be concluded that adding enzyme to the diet can increase profitability in broiler rearing and the rate of this profitability is dependent to the ingredients of feed and the specific enzymes which are used.

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