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Effect of hemicell enzyme on the performance, growth parameter, some blood factors and ileal digestibility of broiler chickens fed corn/soybean-based diets

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The current study aimed to investigate the effects of supplementing diet of broiler chickens with hemicell enzyme on performance, carcass characteristics, growth parameter, blood parameters and ileal digestibility of nutrients. One hundred and eighty day-old Ross 308 strain broiler type chickens were randomly assigned to three treatments with five replicate pens containing 12 birds in each experimental diets containing 0, 0.5, and 1 g/kg of hemicell enzyme. All diets were calculated to be iso-nutritive to meet or exceed the nutrient requirements recommended by the National Research Council (NRC, 1994) for broilers. Growth parameters were estimated for each group using Gompertz model (2008). At day 35, titanium oxide (1 g/kg of feed) was added to all diets for five days and used as an analytical marker to determine digestibility of dry matter, organic matter, crude protein and crude fat. At 6 weeks of age, blood samples were collected via wing vein to harvest plasma for biochemical analyses. During the starter phase, grower phase and the course of study, body weight gain, feed intake and feed conversion ratio (FCR) did not significantly differ among the treatments ($P>0.05$). Hemicell enzyme in broiler diets had no significant effect on dressed weight, kitchen carcass, breast muscle, thigh and gizzard percentages ($P>0.05$), but had significant effect on heart and liver percentages ($P<0.05$). The diets had no significant effect on growth parameters and growth rate of broiler chickens estimated by Gompertz model ($P>0.05$). Dietary inclusion of hemicell enzyme significantly increased plasma concentration of glucose ($P = 0.064$). Plasma concentrations of cholesterol, triglycerides and very low density lipoprotein (VLDL) were not affected by the dietary treatments ($P>0.05$). Plasma concentrations of high density lipoprotein (HDL) and low density lipoprotein (LDL) concentration were significantly affected by enzyme supplementation ($P<0.05$). The ileal digestibility of fat and protein was significantly improved by hemicell enzyme addition ($p<0.05$). The results of this study showed that supplementing broiler diets by hemicell enzyme did not improve production performance and ileal digestibility of crude fat and crude protein in broiler chickens.

Key words: Hemicell enzyme, broiler chickens, growth parameter, blood factors, ileal digestibility.

INTRODUCTION

Efficient conversion of feed into broiler tissue is an essential feature of successful poultry production enterprises. Consequently, the identification of factors inhibiting and conversely alleviating nutrient utilization are of great importance. Soybean meal (SBM) contains a number of antinutritional factors such as non-starch polysaccharides (NSP) and protease inhibitors that may reduce bioavailability of other nutrients (Annison and

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Table 1. Percentage composition of experimental starter and grower diets.

Ingredient	Starter	Grower
Corn	59.00	63.00
Soybean Meal-44	32.03	27.79
Fish Meal	3.00	2.50
Soy Oil	1.81	3.25
Dical. Phos.	1.50	0.90
Oyster shale	1.50	1.55
Vit&Min Premix	0.50	0.50
Common Salt	0.40	0.32
DL-Methionine	0.2	0.1
L-Lysine	0.07	0.09
Calculated composition		
ME (Kcal/kg)	2950	3100
Protein (%)	21.20	19.37
Calcium (%)	1.10	0.96
Phos. (%)	0.50	0.37
Lysine (%)	1.26	1.14
Met + Cys (%)	0.91	0.76

Vit and Min Premix: 11,000 IU; vitamin E, 55 IU; vitamin B12, 0.066 mg; riboflavin, 33 mg; niacin, 165 mg; D-pantothenic acid, 55 mg; menadione, 11 mg; folic acid, 3.3 mg; pyridoxine, 13.75 mg; thiamin, 6.66 mg; D-biotin, 0.28 mg. 3 Supplied per kilogram of diet: manganese, 120 mg; zinc, 100 mg; copper, 10 mg; iodine, 2.5 mg; calcium, 135 mg.

Choct, 1991; Bedford and Classen,1993).

Non-starch polysaccharides are complex carbohydrates found in the structure of plant cell walls with high molecular weight (Classen and Bedford, 1991; Annison and Choct, 1991). Beta-mannan (BM) is a NSP, which is found in various feedstuffs and protein concentrates. The negative effects of BM supplemented to the broiler diets include reduced feed intake, weight gain and feed/gain ratio (Ray et al., 1982; Furuse and Mabayo, 1996).

Enzyme supplementation of poultry rations has been widely reviewed and well documented to improve efficiency of converting feedstuffs into broiler tissue (Annison and Choct, 1991; Campbell and Bedford, 1992; Bedford and Morgan, 1996; Marquardt et al., 1996). Reported benefits include improved weight gain, feed: gain ratio and metabolizable energy (ME) as well as reduced excreta and phosphorous (P) output, water intake, digesta viscosity and gastrointestinal tract (GIT) size (Friesen et al., 1992; Brenes et al., 1993; Annison et al., 1995; Marquardt et al., 1996). Hemicell enzyme is a fermentation product of *Bacillus lentus*, which contains high amounts of β-mannanse that degrade β-mannan in feedstuffs. Mannan from guar gum, galactomannan, has strong anti nutritive factor for mono gastric animals, which interferes with glucose metabolism and insulin secretion rates in swine (Leeds et al., 1980). The suppression of insulin secretion can impair the intestinal uptake and utilization of glucose and amino acids in peripheral tissues such as striated muscle by mono-gastric animals, resulting in reduced growth and feed efficiency (Jackson et al., 1999). The objective of the present study was to investigate the effects of hemicell enzyme on performance, carcass characteristics, growth parameter, blood parameters and ileal digestibility of nutrients in broiler chickens fed soybean (SBM)-corn based diets.

MATERIALS AND METHODS

Birds, feeding and managements

The current study was carried out in two phases: starter (0 to 21 days) and grower (21 to 42 days). One hundred and eighty day-old Ross 308 strain broiler type chickens were randomly assigned to three treatments with five replicate pens containing 12 birds in each. The birds were brooded conventionally in a deep litter system from day-old to 6 weeks of age. Throughout the experiment, the birds were observed daily and a record of mortality was kept. Weight gain and feed intake per bird was determined at weekly intervals and feed to gain ratio was computed accordingly.

Diets were calculated to be iso-nutritive to meet or exceed the nutrient requirements recommended by the NRC (1994) for broilers. The compositions of the starter and finisher diets are shown in Table 1. Experimental diets (diets 1 to 3) contained 0, 0.5, and 1 g/kg of hemicell on dry matter (DM) basis, respectively. Birds had free access to feed and water. At day 42, two birds from each replicates were randomly selected, weighed and killed by cervical dislocation, then defeathered and their dressed weights were recorded. They were quickly split open, the organs removed and weighed. The eviscerate weights of the birds were then recorded.

Growth parameter

To estimate growth parameters, cumulative body weight of birds were fitted to Gompertz model (Lopez, 2008) as shown in the following model:

$$W_t = W_0 \exp\{\{1 - \exp(-bt)\} \ln(W_f/W_0)\}$$

where, W_t is the expected body weight (g) at the week t (day); W_0 is the initial body weight (g), b is the coefficient of relative growth or maturing index (smaller value of b indicates later maturity, while the larger b indicates earlier maturity); t is the age of bird (day) and W_f is the mature body weight (g). The parameters of models were estimated using non-linear (NLIN) procedure of Statistical Analysis System (SAS) Institute (2003) with iterative least squares regression (Gauss-Newton method).

The derived parameters were then used to estimate the inflection point T_i; body weight at the inflection point (g; W_i) and growth rate (GR; g/day) as follows:

$$T_i = 1/b\{\ln(\ln(W_f/W_0)\}$$

$$W_i = 0.368W_f$$

$GR = bW\ln(W_f/W)$ (Aggrey, 2002; Darmani et al., 2003; Alkan et al., 2009).

Blood sampling

When the chicks reached 6 weeks of age, the feeding trial was terminated. Fifteen birds from each treatment group (3 chicks for each replicate) were randomly selected, and their blood samples

Table 2. Effects of hemicell enzyme on performance of broiler chickens in starter, grower and total period.

Performance parameter	Dietary treatment			SEM	P-value
	Diet 1[1]	Diet 2[1]	Diet 3[1]		
Starter phase					
Weight gain	476.74	480.76	483.77	9.632	0.800
Feed Intake	1012.49	1026.47	1033.22	6.94	0.509
FCR	2.04	2.05	2.05	0.040	0.985
Feed cost	3354	3417	3479	-	-
Meat cost	6789	6951	7083	68.03	0.209
Grower phase					
Weight gain	1200.31	1189.28	1239.52	33.88	0.446
Feed Intake	2710.59	2722.05	2808.94	36.38	0.145
FCR	2.42	2.40	2.40	0.047	0.881
Feed cost	3162	3224	3287	-	-
Meat cost	7603	7691	7820	75.18	0.461
0 to 42					
Weight gain	1677.05	1670.04	1723.29	42.71	0.481
Feed Intake	3723.53	3748.52	3842.16	39.23	0.163
FCR	2.23	2.22	2.23	0.042	0.978
Feed cost	3258	3320	3383	-	-
Meat cost	7196	7321	7451	61.94	0.223

FCR: Feed conversion Ratio; SEM: standard error of means; Means within a row with same or no superscripts are not significantly different (P > 0.05). [1]Diets 1, 2 and 3 contained 0, 0.5 and 1 g/kg of hemicell on dry matter (DM) basis, respectively.

were collected via wing vein to collect plasma for biochemical analyses. Plasma samples were analyzed for total cholesterol, glucose, triglycerides, high density lipoproteins (HDL), low density lipoproteins (LDL) and very low density lipoproteins (VLDL) concentrations by diagnostic kits (Pars Azmon, made in Iran) using spectrophotometer.

Collection of samples and measurements

At day 35, titanium oxide (1 g/kg of feed) was added to all diets for five days and was used as an analytical marker to determine digestibility of dry matter, organic matter, crude protein and crude fat. At day 40, three birds per each replicate (15 chicks per each treatment) were randomly chosen, weighed and killed by cervical dislocation and their ileal contents were evacuated. Immediately after collection, the ileal samples were placed into plastic containers and were freeze-dried. Prior to chemical analysis, these samples were ground to pass through a 0.5 mm sieve. Dry matter, organic matter, CP (N × 6.25, MicroKjeldahl) and ether extract (crude fat), were determined in the feed and ileal digesta samples according to standard methods as described by Naumann and Bassler (1976). Diet and ileum titanium contents were analyzed by the procedure of Short et al. (1996).

Statistical analyses

Data were analyzed using the general linear models (GLM) procedure of SAS (SAS Institute, 1993) and the corresponding means were compared by Duncan test. For all statistical analyses, significance was declared at P<0.05 and trends were declared at P<0.1.

RESULTS AND DISCUSSION

The effects of hemicell enzyme on performance of growing broiler chickens are shown in Table 2. During the starter phase (0 to 21 days), body weight gain, feed intake and FC R for the treatments were not significantly affected by the dietary treatments (P>0.05). Birds fed diet 3 (1 g/kg enzyme) had the highest body weight gain (WG; 433.17 g) and feed intake (FI;1033.22 g), while birds fed diets 1 (control) had the best feed conversion ratio (FCR; 2.04). During the grower phase (21 to 42 days), body weight gain, feed intake and FCR for the treatments were not significantly different (P>0.05). Birds fed diet 3 (1 g/kg hemicell enzyme) had the highest WG (1329.52 g) and FI, (2808.94 g). In this phase, birds fed with control diet (non-hemicell supplemented diets) had the highest FCR as compared to the other birds (P>0.05). During the whole of experiment (0 to 42 days), WG, FI, FCR and meat cost were not significantly different among the dietary treatments (P>0.05).

The results of this experiment indicate that the addition of hemicell enzyme at the levels of 0.5 or 1 g/kg to a soybean-corn based diet did not improve WG, FI and FCR of broilers during the starter and grower phases of growth. In agreement with our results, Ravindran et al. (1999) did not find any beneficial effects on production performance of broiler chickens when they were fed with

Table 3. Carcass characteristics of birds on experimental diets (percentage of dressed weight).

Parameter	Dietary treatments			SEM	P-value
	Diet 1[1]	Diet 2[1]	Diet 3[1]		
Dressed weight (%LW)	90.62	86.34	88.98	1.87	0.65
Kitchen carcass weight(%DW)	69.47	62.67	56.48	2.26	0.08
Thigh (%DW)	30.27	29.19	27.71	0.47	0.078
Breast (%DW)	21.41	20.50	21.50	0.39	0.54
Gizzard (%DW)	3.98	4.10	3.88	0.12	0.63
Liver (%DW)	2.62[ab]	2.87[a]	2.44[b]	0.10	0.023
Heart (%DW)	0.78[ab]	0.99[a]	0.64[b]	0.052	0.017

LW: Live weight; DW: dressed weight; Means within a row with same or no superscripts are not significantly (P > 0.05) different; SEM: Standard error of means. [1]Diets 1, 2 and 3 contained 0, 0.5 and 1 g/kg of hemicell on dry matter (DM) basis, respectively.

cereal-based diets (corn, wheat or barely) supplemented with xylanase. In contrast to our findings, Zou et al. (2006) found that hemicell greatly improved FCR when supplemented with corn-soybean diets at an inclusion rate of 0.05% of the diet. Jackson et al. (2004) also reported that inclusion of β-mannanase at 80 million U/ton improved FCR at 42 days. McNaughton et al. (1998) found that broiler chickens fed corn-SBM based diets with hemicell had higher average daily gain (ADG), lower feed/gain and higher energy digestibility as compared to the birds fed non-supplemented diets.

It was shown that feeding swine with diets containing soybean meal lowered insulin secretion and reduced glucose absorption due to its mannan content (Leeds et al., 1980; Rainbird et al., 1984). Therefore, it has been postulated that addition of hemicell may ameliorate insulin secretion and glucose absorption by hydrolyzing β-mannan (Zou et al., 2006), thereby improving energy metabolism. However, in this study, addition of 0.05 and 0/1% hemicell failed to elicit any response. Moreover, hemicell supplementation did not improve weight gain (WG) at starter and grower phases. The results are inconsistent with findings of Saki et al. (2005). They reported that when hemicell was added to the diet, 42-day BW of broilers was increased by 60 g/bird. The other researchers also found improved 42-day BW of birds when β-mannan containing diets were supplemented with hemicell (Jackson et al., 2004; Saki et al., 2005; Zou et al., 2006). This was most likely due to improved energy utilization in birds as indicated earlier.

when Compared with the control group, the cost of feed increased with increasing the dietary level of hemicell enzyme (Table 2). However, the cost of meat production was similar between the groups (P>0.05; Table 2). This was consistent with the results of Saki et al. (2005) and Zou et al. (2006). They also reported that supplementing broiler diet with β-mannanase at 0.05% of diet did not have any effect on meat cost at 21 and 42 days.

Inclusion of hemicell enzyme in broiler diets at the levels 0.05 or 0.1 (g/kg) had no significant effect on dressed weight, kitchen carcass, breast muscle, thigh and gizzard percentage (P>0.05; Table 3), but significantly affected heart and liver percentages (P<0.05). The birds fed diet containing 0.05 g/kg enzyme had a higher liver and heart percentages than those fed with the diet containing 1 g/kg enzyme (P<0.05; Table 3). Our results were in agreement with findings of Biswas et al. (1999) who reported that carcass yield was similar among enzyme treated and non-treated diets. However, Hajati (2010) reported that enzyme supplementation increased carcass percentage and thighs percentage but had no effect on breast, wings, heart, liver, proventriculus and gizzard percentages.

Overall means and standard error of means (SEM) of body weight for dietary treatments are presented in Table 4. In all the treatments, the standard error of means increased with age.

In the present study, the growth parameters of broiler chickens were estimated using a non-linear Gomperz model. The estimated parameters are shown in Table 5. Numerous growth equations have been developed to describe and fit the nonlinear sigmoid relationship between growth and time (Roush and Branton, 2005). Growth curves for poultry generally have the following characteristics: an accelerating phase of growth from hatching, a point of inflection in the growth curve at which the growth rate is maximum, a phase where growth rate is decelerating, and a limiting value (asymptote), mature weight (Roush and Branton, 2005). The result showed the W_0, b W_f, T_i and W_i (P>0.05).

The estimated growth rates (GR) of broilers fed different diets are shown in Table 6. Dietary treatment had no effect on the estimated growth rates of birds (P>0.05).

Dietary addition of hemicell enzyme significantly increased plasma concentration of glucose (P = 0.064; Table 7). Plasma concentrations of cholesterol, triglycerides and VLDL were not affected by the dietary treatments (P>0.05; Table 7). Plasma concentration of HDL was significantly different among the experimental treatments (P<0.05; Table 7). The control diet had a significantly higher HDL concentration than the other diets (P<0.05; Table 7). The birds fed with diet containing 0.5

Table 4. Means, minimum, maximum, and standard error means for body weight of broiler chicken fed with Hemicell enzyme at different ages.

H.E (g/kg)	parameter	Age					
		7 Day	14 Day	21 Day	28 Day	35 Day	42 Day
0	Min	144.5	319	561	833	1357	2003
	Max	147.2	337	660	957.7	1428	2218
	Mean	145.6	329.6	600.7	926.2	1401.3	2087
	SEM	0.084	5.45	30.21	22.37	22.3	66.36
0.5	Min	133.6	322	574.4	911.1	1345.5	1903.3
	Max	155	342	585.5	950	1435.5	2060
	Mean	146.2	330.6	580.3	928.5	1378.1	1963.1
	SEM	6.45	5.92	3.23	11.41	28.79	48.85
1	Min	143.6	324	562	930	1440	2045
	Max	156.3	346	620	982.2	1504.4	2151
	Mean	150	334.3	589.3	953.4	1463.1	2082.4
	SEM	3.67	6.38	16.82	15.31	20.69	34.33

Min: Minimum, Max: maximum, SEM: Standard error of means.

Table 5. Effects of hemicell enzyme on growth parameters of broiler chickens.

H.E	Parameter				
	W_0 (g)	b	W_f (g)	T_i (day)	W_i (g)
0	61.22	0.0283	6266.3	55.035	2817.6
500	60.80	0.0300	6436.5	54.053	2570.6
1000	58.81	0.0300	6317.4	52.925	2496.6
SEM*	1.355	0.00088	267.51	1.66	165.86
P-V	0.6713	0.6747	0.9596	0.8921	0.7738

Means within a column with same or no superscripts are not significantly (P > 0.05) different; H.E: Hemicell enzyme, W_0 = hatch weight, b: growth constant, W_f: body weight at maturity, T_i: time inflection, W_t= weight at inflection point, SEM: Standard error of means, P-V: p-value.

Table 6. Effects of hemicell enzyme on growth rate of broiler chickens.

H.E	Period						
	GR_1	GR_7	GR_{14}	GR_{21}	GR_{28}	GR_{35}	GR_{42}
0	6.41	15.87	27.45	38.42	48.61	59.56	69.09
500	6.53	16.15	27.97	38.68	48.95	58.97	66.36
1000	6.69	16.51	28.81	39.76	49.23	61.13	68.83
SEM*	0.13	0.30	0.64	1.02	1.33	1.69	2.19
P-V	0.446	0.360	0.082	0.225	0.964	0.614	0.793

Means within a column with same or no superscripts are not significantly (P > 0.05) different. H.E: Hemicell enzyme, $GR_{1\ to\ 42}$: growth rate 1 to 42 day; *SEM: Standard error of means, P-V: p-value.

g/kg enzyme had a significantly higher plasma concentration of LDL as compared to the other birds (P<0.05; Table 7). Hajati (2010) reported that adding multi-enzyme to broilers' diet significantly increased blood concentrations of total cholesterol, glucose and triglyceride at 44 days of age.

Supplementing diets of young chicks with exogenous enzymes may improve nutrient digestibility in at least two ways: (1) by supplying enzymes that the chicks cannot produce in sufficient quantity by itself, or (2) by sparing nutrients and energy needed for synthesis of endogenous enzymes, thus making more nutrients and energy availa-

Table 7. Effects of hemicell enzyme on blood parameters of broiler chicken.

Parameter	Enzyme (g/kg)			SEM*	P-Value
	0	0.5	1		
Glucose (mg/100 ml)	229.86	235.65	251.31	4.675	0.064
Cholesterol (mg/100 ml)	152.31	146.08	132.02	5.937	0.340
Triglycerides (mg/100 ml)	40.95	43.08	42.87	2.224	0.871
HDL(mg/100 ml)	70.94[a]	56.88[b]	68.88[a]	2.488	0.035
LDL (mg/100 ml)	72.35[a]	83.03[a]	43.86[b]	4.336	0.001
VLDL (mg/ 100 ml)	29.01	29.21	26.40	1.256	0.623

HDL = High-density lipoprotein; LDL = low-density lipoprotein; VLDL = very low-density lipoprotein; SEM = Standard error of means.

Table 8. Effects of hemicell enzyme on ileal digestibility of crude fat, crude protein, dry matter and organic matter in broiler chicken.

Parameter	Enzyme (g/kg)			SEM*	P-Value
	0	0.5	1		
Crude fat (%)	63.49[b]	65.31[b]	77.54[a]	2.33	0.001
Crude protein (%)	68.51[b]	74.29[a]	79.27[a]	1.63	0.002
Dry matter (%)	76.32	82.59	79.63	0.387	0.062
Organic matter (%)	72.75	77.67	79.78	1.61	0.128

SEM = Standard error of means.

ble for growth of the chick at the critical stages (Hajati, 2010). This may to somewhat explain why plasma concentration of glucose tended to be higher in hemicell-supplemented birds as compared to the control birds (Table 7).

The results of this experiment showed that dietary supplementation with hemicell enzyme significantly improved ileal digestibility of crude protein as compared to the control group (P<0.05; Table 8). However, ileal digestibility of crude fat was improved only when hemicell was added to the diet at the level of 1 g/kg DM of diet (Table 8). Our findings were in agreement with the results of other researchers who found that dietary supplementation with exogenous enzymes improves ileal digestibility of dietary proteins (Delang et al., 1998; Gdala et al., 1997; Papadopoulos, 1998; Wright, 1995; Yaser, 2002).

Ileal digestibility of crude fat in birds fed diet containing 1 g/kg DM of hemicell was significantly higher than those fed control diet (Table 8). Enzyme supplementation can break down plant cell wall, reduce its integrity and thus release its nutrients contents, which makes them more available for digestive enzymes. This may improve the digestibility of nutrients (Bedford, 2000). Indeed, our findings showed that ileal digestibility of crude fat and crude protein was improved when hemicell was added to the diet at the level of 1 g/kg DM (Table 8).

Conclusion

Overall, the results of the present study indicated that dietary supplementation with hemicell had no effect on WG, FI and FCR. Except for heart and liver percentages, experimental diets did not have any significant effects on carcass characteristics. Estimated growth parameters were not affected by dietary inclusion of hemicell. Dietary supplementation with hemicell tended to increase plasma concentration of glucose. Plasma concentrations of HDL and LDL were significantly affected by the dietary treatments. In the current study, supplementing a soybean-corn based diet with hemicell at the inclusion level of 1 g/kg DM improved ileal digestibility of crude fat and crude protein.

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