J. Agric. Sci. Mansoura Univ., 34 (4): 2819 - 2834, 2009

PERFORMANCE OF BROILER CHICKS FED PLANT PROTEIN DIETS SUPPLEMENTED WITH COMMERCIAL ENZYMES

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ABSTRACT

The present study was carried out to investigate the performance of broiler chicks fed isocaloric experimental diets (3170 k cal/kg) containing 18%- or 20%-plant protein, during the growing period (15 to 42 days of age) in absence or presence of exogenous commercial enzyme preparations (Phytase, Natuzyme, Sicozyme or Avizyme) at a level of 0.5 g/kg diet. Three hundred and sixty one-day old Cobb-500 broiler chicks were kept in battery brooders and fed a common starter diet (ME; 3000 k cal/kg and 21.57% CP) up to 14 days of age. Then, they were transferred wire-floored growing batteries, according to a factorial design (2×5) were distributed into ten equal groups of three replications each, and fed their respective experimental diets up to 42 days of age. All chicks had free access to feed and water and managed similarly.

The criteria of response were live body weight, weight gain, feed intake, feed conversion, economic efficiency, carcass traits, nutrient digestibility and some blood parameters (plasma levels of glucose, total protein, total lipids and cholesterol as well as activity of alkaline phosphatase, alanine aminotransferase and aspartate aminotransferase in blood plasma of chicks). The obtained results could be summarized as follows: Regardless of the effect of dietary enzyme supplementation, broiler chicks fed the 20%CP-diets consumed significantly more feed and exhibited superior means of final live body weight, weight gain, feed conversion, nitrogen retention and CP digestibility as compared to those fed the 18%CP-diets. Apart from the effect of dietary protein level, adding either type of enzyme preparations to the diets produced significant positive effects on final live body weight of chicks, and equally exerted significant beneficial effect on digestibility of CP and EE, and nitrogen retention as compared to those fed the non-supplemented diets. Neither dietary protein level nor supplemental enzymes gave significant differences in economic efficiency, carcass traits and blood constituents of chicks.

From the previous results, it could be concluded that in these plant-protein experimental diets the level of 20% CP was more suitable achieving satisfactory growth performance of broiler chicks during the grower period. In addition, dietary enzyme supplementation had some positive effect on chicks' growth performance. Natuzyme and Sicozyme brought about the best results with the present experimental diets.

Keywords: Dietary protein level, enzyme supplementation, broiler performance, carcass traits.

INTRODUCTION

Feed ingredients of plant origin contain a number of components that are refractive to monogastric digestive enzymes because of lack of and/or insufficiency of endogenous enzyme secretions (Ravindran *et al.,* 1999). These components also reduce the utilization of nutrients, leading to a depressed bird performance. Examples of such antinutritive components include β-glucans in barley, pentosans in wheat, and certain oligosaccharides in soybean meal (Annison and Choct, 1991). Therefore, development of commercially available exogenous enzyme preparations to target specific substrates in the feeds and ameliorate their antnutritive effects has received increased attention in the last decade.

Adding enzymes into broiler diets is usually applied in order to increase their nutritive values with the aim of increasing the potential of meat production. This is especially interesting if the used enzymes are specific to certain dietary compounds in feeds of lower nutritive value. Several reports have indicated that utilization of such commercial enzyme preparations can improve the productive performance of birds (Cowieson *et al*., 2000, Cmiljanić *et al*., 2001, Perić *et al.,* 2008). However, some investigators observed no positive effects of dietary enzyme supplementation for broilers (McNab and Bernard, 1997; Perić *et al.,* 2002; Iji *et al*., 2003, Zakaria *et al*., 2008). Generally, the positive effect of these additives depends on the quantity and quality of feed ingredients, the dietary energy level, and type and composition of enzyme preparation, as well as fattening conditions (Acamovic, 2001).

Therefore, the present study was performed to investigate the response of broiler chicks to feeding of 18%- or 20%-plant-protein diets along with dietary supplementation with different types of commercial enzyme preparations (Phytase, Natuzyme, Sicozyme or Avizyme) from 15 to 42 days of age. The response was evaluated in terms of growth performance, nutrient digestibility, carcass traits and some blood measurements.

MATERIALS AND METHODS

The present study was carried out at the Poultry Research Unit, Agricultural Research and Experimental Station, Faculty of Agriculture, Mansoura University, Egypt.

Birds, diets and management:

Three hundred and sixty one-day-old Cobb-500 broiler chicks were used in this study. The chicks were kept in brooding batteries and fed a common starter diet (ME; 3000 k cal/kg and 21.57% CP) up to 14 days of age. At 15 days of age, the chicks were randomly divided into ten equal experimental groups (3 replicates per treatment) and transferred to conventional wire-floored rearing batteries and fed their respective experimental diets to the end of the experiment (42 days of age). Two isocaloric (ME of about 3170 k cal/kg) grower experimental diets containing 20% or 18% crude protein (CP) were formulated, and in a 2×5 factorial design of treatments were supplemented or not with one of four types of commercial enzyme preparations (Phytase, Natuzyme, Sicozyme and Avizyme) at a level of 0.5 g/kg diet at the expense of yellow corn. The chicks had free access to feed and water during both the starter and grower-finisher periods and managed similarly. Diets formulations were performed on the basis of the tabulated data of nutrient composition of feed ingredients published by NRC (1994). Composition and chemical analysis of the experimental diets are presented in Table 1.

Table 1: Composition of the experimental diets for broiler chicks

Ingredients %	Starter diet	Grower 20% CP*	Grower 18% CP*
Yellow corn	63.45	70.95	75.08
Soybean meal (44%)	20.70	8.00	7.00
Corn gluten meal (62%)	10.50	16.00	12.75
Dicalcium phosphate	2.50	2.30	2.30
Limestone	1.50	1.50	1.50
Common salt	0.40	0.40	0.40
Premix**	0.40	0.40	0.40
DL-Methionine	0.15	---	0.08
L-Lysine-HCl	0.40	0.45	0.49
Total	100	100	100
Price of kg diet; LE	----	1.82	1.79
Calculated analysis (air dry basis: NRC, 1994)			
ME; kcal/kg	3001	3171	3171
Crude protein; %	21.57	20.00	18.00
Ether extract; %	2.84	3.16	3.23
Crude fiber; %	2.98	2.33	2.31
Ca; %	1.19	1.11	1.11
Non-phytate P; %	0.54	0.49	0.48
Lysine; %	1.23	1.01	1.01
Methionine; %	0.55	0.42	0.45
Meth. & cystine	0.92	0.77	0.77
Determined analysis (dry matter basis: AOAC, 1990)			
Dry matter %	91.17	90.89	90.92
Ash %	6.73	6.91	6.89
CP %	23.43	21.84	19.70
EE %	3.21	3.54	3.57
CF %	3.35	2.60	2.64
NFE %	63.28	65.11	67.20

***These diets were used without or with the following enzyme preparations: Avizyme, Phytase, Sicozyme and Natuzyme at level of 0.5kg/ton feed at the expense of the same amount of yellow corn.**
Each kg of Avizyme-1500 contains: Amylase, 400000 U; Xylanase, 300000 U and Protease, 4000000 U.
Phytase: 2500000 FYT/kg.
Each kg of Sicozyme contains: β-glucanase, 40000 U; Protease, 10000 U; Pectinase, 40000 U and Amylase, 8000000 U.
Each kg of Natuzyme contains: Xylanase, 4500000 U; Cellulase, 4200000 U; Phytase, 200000 U; Alpha-amylase, 700000 U; Pectinase, 50000 U and β-glucanase, 500000 U; in addition to some activity of Protease, Hemi-cellulase and Amylo-glycosidase.
**** Each 3 kg premix contains: Vit. A, 12000000 IU; Vit. D_3, 2500000 IU; Vit. E, 10 g; Vit. K, 2.5 g; Vit. B_2, 5.0 g; Vit. B_6, 1.5 g; Vit. B_{12}, 10 mg; Biotin, 50 mg; Folic acid, 1.0 g; Nicotinic acid, 30 mg; Pantothenic acid, 10 g; Antioxidant, 10 g; Mn, 60 g; Cu, 10 g; Zn, 55 g; Fe, 35 g; I, 1.0 g; Co, 250 mg and Se, 150 mg.**

Performance of chicks:

During the whole experimental period (15-42 days of age) the criteria of chicks performance included live body weight, body weight gain, feed intake and feed conversion as well as economic efficiency. Weekly records on live body weights of chicks and feed intake were maintained on a replicate group basis. Thus, body weight gain and feed conversion were determined weekly.

Mortality was monitored and recorded daily. Net profit per kg gain was calculated as price of kg gain minus feed cost per kg gain. Cost per kg diet (Table1) and values of feed conversion for the three replicates of each dietary treatment were used to calculate the feed cost per kg gain. Economic efficiency was calculated as net profit per kg gain times 100 divided by cost per kg diet.

Digestibility trials:

During the 6th week of age, digestibility trials were conducted for evaluating nutrient digestibility coefficients of the experimental diets. A group of 6 birds from each treatment was selected on the basis of average body weight, kept in a separate compartment of the battery, fitted with galvanized metal trays for excreta collection, and fed its respective experimental diet for a period of three days. During that period, excreta of chicks were quantitatively collected and feed consumption data were recorded. Excreta samples were immediately dried and kept in pledge of chemical analysis. The proximate analyses for the experimental diets and dried excreta were determined according to the official methods of analysis (AOAC, 1990). In order to estimate protein digestibility, fractions of fecal and urinary nitrogen in the excreta were chemically separated according to the method of Jakobsen *et al.* (1960). The percent of urinary organic matter was calculated by multiplying the percent of urinary nitrogen by the factor 2.62 (Abou-Raya and Galal, 1971). Digestibility coefficients were calculated for dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF), and nitrogen-free extract (NFE). Percentages of nitrogen and ash retention were also calculated.

Carcass traits:

At the end of the experiment (42 days of age), six birds were selected from each treatment on the basis of average weight, and immediately sacrificed by decapitation. Then, their carcasses were scalded, feather-plucked and eviscerated. Procedures of cleaning out and excising of the abdominal fat content were performed on hot carcasses. Records on individual weights of eviscerated carcass and edible organs (heart, liver without gall bladder and skinned empty gizzard) and abdominal fat pad were maintained. The abdominal fat pad included the adipose tissues surrounding the gizzard and the bursa of Fabricius and cloaca. Total edible parts were calculated as eviscerated carcass plus giblets. All measurements of carcasses and components were expressed relative to live weight at slaughter.

Blood parameters:

At 42 days of age, six blood samples per treatment were collected in heparinized tubes from the wing veins of birds. Then, plasma was separated by centrifugation (at 3000 rpm for 15 minutes) and stored at –20^{o}C for later analysis. Individual plasma samples were analyzed, using commercial kits, for the determination of plasma levels of glucose, cholesterol, total protein and total lipids as well as activity of the enzymes: alkaline phosphatase, and aspartate aminotransferase (AST) and alanine aminotransferase (ALT), according to the methods of Trinder (1969), Allain *et al.* (1974), Henry (1964), Frings and Dunn (1970), Kind and King (1954) Reitman and Frankel (1957), respectively.

Statistical analyses:

A completely randomized design with a factorial arrangement of treatments (2×5) was subjected to ANOVA. Data were processed using Quattro Program software (Borland International, Inc., 1990). Statistical analysis of the results was performed using Statgraphics Program software (Rockville, 1991). The significant differences among means of treatments for each criterion were identified at $P \leq 0.05$ by LSD-multiple range test.

RESULTS AND DISCUSSION

Performance of chicks:

Data on the performance (live body weight, weight gain, feed intake and feed conversion) of broiler chicks are presented in Tables 2 and 3, respectively. Regardless of the effect of dietary enzyme supplementation, statistical analysis showed that chicks fed the 20%-CP-diets exhibited significantly higher ($P \leq 0.01$) means of live body weight compared with those of chicks fed the 18%-CP-diets at the 3rd, 4th, 5th and 6th weeks of age. Superior body weight gains ($P \leq 0.01$) were also recorded for chicks fed the 20%-CP-diets through 2-3, 4-5 and 2-6 weeks of age as compared to those of birds fed the 18%-CP-diets. Although chicks fed the 20%-CP-diets consumed significantly ($P \leq 0.01$) more feed during the whole experimental period compared with that of chicks fed18%-CP-diets, the former exhibited better ($P \leq 0.05$) feed conversion than the latter.

On one hand, dietary enzyme supplementation had positive effects on live body weight and weight gain of broiler chicks during the whole period of study (2- 6 weeks of age), irrespective of the effect of dietary protein level. However, on the other hand, feed intake and feed conversion were not affected by dietary enzyme supplementation. Compared with the unsupplemented birds, the highest means of live body weight and weight gain were recorded for the experimental groups of chicks fed the Sicozyme-, Natuzyme- and Phytase-supplemented diets in a descending order, respectively, with no significant differences among them. It is worthy to mention that mortality rate was too low and not related to the effect of dietary treatments.

The obtained results agree with those of Dastar *et al.* (2008) who found that broilers fed low protein (90% of the NRC recommended level) had lower performance than those fed diets containing the NRC requirements of protein. Also, even though Nguyen and Bunchasak (2005) found that dietary protein levels higher than 17% CP did not show any significant effect on growth performance, they concluded that increasing dietary protein levels positively improved growth performance and feed utilization of Betong chicks.

Since there were no significant differences in feed intake and feed conversion of chicks in response to feeding the enzyme-supplemented diets in the present study, one would speculate that the observed beneficial effects on growth performance (from 2 to 6 weeks of age) may be attributed to an improved nutrient digestibility of such diets (*i.e.* higher means of CP and EE digestibility and N retention) as given in Table 5. In the present study, the positive effects of dietary enzyme supplementation on growth performance are in partial agreement with the findings reported by Café *et al.* (2002), Alam *et al.* (2003), Khan *et al.* (2006), Pourreza *et al.* (2007), Perić *et al.* (2008), Ghorbani *et al*. (2009) and Zhou *et al.* (2009). Contrarily, some investigators observed no positive effects of dietary enzyme supplementation for broilers (McNab and Bernard, 1997; Perić *et al.,* 2002; Iji *et al*., 2003, Sayyazadeh *et al.*, 2006; Zakaria *et al*., 2008).

Table 2: Live body weight and weight gain of broiler chicks fed experimental grower-finisher diets supplemented with different enzyme preparations

Treatments	**Weekly live body weight (g)**					**Weekly body weight gain (g)**				
	2	**3**	**4**	**5**	**6**	**2-3**	**3-4**	**4-5**	**5-6**	**2-6**
Protein level (A)										
1 18%	397	641^{b}	1063^{b}	1508^{b}	2005^{b}	244^{b}	422	445^{b}	497	1608^{b}
2 20%	396	699^{a}	1153^{a}	1678^{a}	2183^{a}	303^{a}	454	524^{a}	505	1787^{a}
SEM[1]	1.1	7.6	14.9	20.2	13.8	7.2	11.9	16.9	17.1	13.3
Significance level	NS	**	**	**	**	**	NS	**	NS	**
Enzymes (B)										
1 Without	394	653	1094	1540	2014^{c}	259	442	445	474	1620^{c}
2 Phytase	395	647	1106	1585	2099^{ab}	252	458	480	514	1704^{ab}
3 Natuzyme	397	677	1137	1628	2139^{a}	281	459	491	511	1742^{a}
4 Sicozyme	396	678	1117	1631	2149^{a}	283	439	513	519	1754^{a}
5 Avizyme	399	693	1086	1581	2068^{bc}	294	393	495	487	1669^{bc}
SEM[1]	1.8	12.1	23.5	32.0	21.8	11.3	18.9	26.8	27.0	21.1
Significance level	NS	NS	NS	NS	**	NS	NS	NS	NS	**
AB Interactions										
T1 1×1	399	603	997	1404	1836	204	394	407	432	1438
T2 1×2	393	615	1043	1458	1990	222	428	415	532	1597
T3 1×3	395	661	1089	1567	2072	266	428	478	506	1677
T4 1×4	397	650	1075	1526	2068	253	425	451	542	1671
T5 1×5	401	676	1111	1587	2058	275	435	475	472	1657
T6 2×1	390	703	1192	1676	2191	313	489	485	515	1802
T7 2×2	397	679	1168	1713	2208	282	489	544	496	1811
T8 2×3	399	694	1185	1689	2206	295	490	504	517	1806
T9 2×4	393	707	1159	1735	2231	313	453	575	496	1837
T10 2×5	397	710	1061	1575	2078	313	351	513	503	1681
SEM[1]	2.6	17.1	33.2	45.2	30.8	16.0	26.7	37.9	38.2	29.9
Significance level	NS	NS	*	*	**	NS	*	NS	NS	**

For each of the main factors, means having different superscripts in the same column are significantly different ($P \leq 0.05$).

NS: not significant; *: significant at $P \leq 0.05$; **: significant at $P \leq 0.01$. [1]: SEM= standard errors of the means.

In this regard, Café *et al.* (2002) found that broiler chicks fed Avizyme supplemented diets had significantly higher body weights as compared to birds fed the unsupplemented diets. Alam *et al.* (2003) evaluated the growth performance of broiler chicks fed diets supplemented with three enzyme preparations, and reported that growth rate and feed conversion were improved by addition of the exogenous enzymes. In a recent study, Khan *et al.* (2006) studied the influence of exogenous enzymes supplementation to sunflower-corn based diet on digestive and performance traits in broilers, and found that birds fed the enzyme- supplemented diets ate more and grew faster and had better feed conversion than those fed the control diet. In addition, Pourreza *et al.* (2007) demonstrated that body weight, body weight gain and feed conversion, as well as digestibility of energy and protein were improved due to dietary enzyme supplementation of broiler chicks.

Table 3: Feed intake and feed conversion of broiler chicks fed experimental grower-finisher diets supplemented with different enzyme preparations

Treatments	Weekly feed intake/bird (g)					Weekly feed conversion (g feed: g gain)				
	2-3	**3-4**	**4-5**	**5-6**	**2-6**	**2-3**	**3-4**	**4-5**	**5-6**	**2-6**
Protein level (A)										
1 18%	439	750	830[b]	981	3000[b]	1.809[b]	1.790	1.875	1.997	1.867[b]
2 20%	467	776	945[a]	1009	3197[a]	1.549[a]	1.730	1.816	2.014	1.791[a]
SEM[1]	12	11	20	23	33	0.034	0.036	0.046	0.064	0.021
Significance level	NS	NS	**	NS	**	**	NS	NS	NS	*
Enzymes (B)										
1 Without	424	762	810	979	2975	1.672	1.755	1.843	2.098	1.846
2 Phytase	449	762	917	999	3126	1.808	1.667	1.926	1.944	1.835
3 Natuzyme	478	788	913	983	3162	1.705	1.729	1.868	1.937	1.818
4 Sicozyme	456	778	936	1018	3188	1.631	1.791	1.843	1.978	1.821
5 Avizyme	460	725	863	994	3042	1.579	1.859	1.747	2.073	1.825
SEM[1]	19	17	32	36	53	0.054	0.057	0.073	0.101	0.033
Significance level	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AB Interactions										
T1 1×1	378	733	758	919	2789	1.845	1.891	1.893	2.177	1.938
T2 1×2	411	728	750	997	2886	1.880	1.702	1.835	1.871	1.810
T3 1×3	467	758	896	1017	3138	1.756	1.779	1.875	2.012	1.871
T4 1×4	456	772	886	1031	3144	1.806	1.833	1.963	1.927	1.882
T5 1×5	483	758	861	939	3042	1.760	1.746	1.809	2.001	1.836
T6 2×1	469	792	861	1039	3161	1.499	1.620	1.793	2.018	1.755
T7 2×2	486	797	1083	1000	3367	1.736	1.633	2.018	2.017	1.860
T8 2×3	489	817	931	950	3186	1.655	1.678	1.860	1.862	1.764
T9 2×4	456	785	986	1006	3232	1.457	1.749	1.723	2.029	1.760
T10 2×5	437	692	864	1050	3042	1.398	1.971	1.685	2.145	1.814
SEM[1]	28	24	45	51	75	0.076	0.081	0.103	0.143	0.047
Significance level	NS	NS	*	NS	*	NS	NS	NS	NS	NS

For each of the main factors, means having different superscripts in the same column are significantly different ($P \leq 0.05$).

NS: not significant; *: significant at $P \leq 0.05$; **: significant at $P \leq 0.01$. [1]: SEM= standard errors of the means.

Recently, Perić *et al.* (2008) reported that application of enzyme preparation resulted in positive effects on body weight gain and feed conversion, regardless if it was added to standard mixtures or mixtures of diminished nutritive value. More recently, Ghorbani *et al*. (2009) investigated the effects of substitution of rape seed meal for soybean meal and dietary supplementation with two types of enzymes on broiler performance, and found that body weight gain was significantly increased by dietary supplementation with Grindazyme but was not affected by addition of Phytase in the diet. In addition, Zhou *et al.* (2009) observed superior means of CP retention and apparent metabolizable energy value of broiler chicks in response to dietary enzyme-supplementation.

There were significant interactions between dietary protein level and enzyme supplementation on live body weight, body weight gain and feed intake during the whole experimental period (Tables 2 and 3).

Carcass traits:

The results of carcass traits of 42-day-old broiler chicks fed experimental grower-finisher diets supplemented with different enzyme preparations are presented in Table 4. The average live body weights at slaughter were significantly different due to the effect of dietary protein level, which were 2243 and 2138 g for chick fed 20% and 18% CP-diets, respectively. However, the differences in carcass parts and organs due to the effect of dietary crude protein level were not significant. Also, the abdominal fat contents were 1.69% and 1.82%, for chicks fed 20% and 18% CP-diets, respectively, with no significant differences between them. Meanwhile, total edible parts were 74.8% and 74.6% for those fed 20% and 18% CP-diets, respectively, without significant differences between them.

In the present study, dietary enzyme supplementation had no significant effect on carcass traits, including relative weights of dressed carcass, liver, giblets, breast and legs, total edible parts and abdominal fat pad. It was interesting to note that the yield of total edible parts ranged from 74.4% (Avizyme group) to 75.0% (Sicozyme group), however, the abdominal fat ranged from 1.63% (in the control group) to 1.82% (in Phytase and Natuzyme groups), with no significant differences among them. The effects of dietary protein level and supplemental enzyme on carcass traits were not interrelated (Table 4).

Rezaei *et al.* (2004) reported that decreasing dietary protein had no significant effect on breast meat yield in broiler chicks, but increased abdominal fat percentage significantly. The latter part of this conclusion is in partial agreement with the present results which showed that abdominal fat contents were 1.69% and 1.82%, for chicks fed 20% and 18% CP-diets, respectively without significant differences. Also, Sterling *et al.* (2006) found that increasing dietary crude protein decreased abdominal fat percentage in broiler carcass.

The lack of significant differences in carcass traits of broiler chicks, reported herein, is in harmony with the findings of Sayyazadeh *et al.* (2006), who indicated that adding enzymes to broiler diets had no effect on weights of carcass yield, liver, gizzard and abdominal fat contents. The present results are also in partial agreement with those obtained by Ghorbani *et al*. (2009), who observed no significant differences in weights of carcass yield and carcass components but abdominal fat content was increased as a consequence of feeding enzyme-supplemented diets. However, Café *et al.*

(2002) reported that addition of Avizyme to broiler diets had no consistent effect on dressing percentage of broiler chicks, but abdominal fat, expressed as percentage of carcass weight, was consistently increased. They also suggested that birds fed the diets containing Avizyme obtained a greater amount of net energy from their diets. On the other hand, Alam *et al.* (2003) found that dressing percentage and profitability were increased in response to the addition of exogenous enzymes to broiler diets. In addition, Khan *et al.* (2006) indicated that dietary enzyme supplementation improved dressing percentage but reduced the relative weights of gizzard and proventriculus.

Table 4: Relative weights of carcass traits of 6-week-old broiler chicks fed experimental grower-finisher diets supplemented with different enzyme preparations

Treatments	Live weight (g)	Liver weight (%)	Giblets weight (%)	Breast (%)	Legs (%)	Dressed weight (%)	Total edible parts (%)	Abdominal fat pad (%)
Protein level (A)								
1 18%	2138[b]	2.45	4.51	55.9	44.1	70.1	74.6	1.82
2 20%	2243[a]	2.47	4.56	56.9	43.0	70.4	74.8	1.69
SEM[1]	31	0.05	0.06	0.39	0.39	0.23	0.23	0.09
Significance level	*	NS	NS	NS	NS	NS	NS	NS
Enzymes (B)								
1 Without	2163	2.50	4.52	55.6	44.4	70.4	74.9	1.63
2 Phytase	2177	2.32	4.33	56.3	43.7	70.2	74.6	1.82
3 Natuzyme	2229	2.56	4.57	56.5	43.5	70.2	74.7	1.82
4 Sicozyme	2168	2.48	4.50	56.7	43.3	70.5	75.0	1.78
5 Avizyme	2216	2.44	4.51	56.9	43.0	69.9	74.4	1.72
SEM[1]	48	0.08	0.09	0.63	0.63	0.37	0.37	0.15
Significance level	NS	NS	NS	NS	NS	NS	NS	NS
AB Interactions								
T1 1×1	2137	2.54	4.61	54.0	45.9	70.0	74.6	1.69
T2 1×2	2100	2.34	4.48	55.2	44.8	70.3	74.8	1.87
T3 1×3	2183	2.52	4.50	56.0	43.9	69.8	74.3	1.82
T4 1×4	2139	2.50	4.59	56.6	43.4	70.3	74.9	1.91
T5 1×5	2133	2.35	4.39	57.6	42.4	70.1	74.5	1.83
T6 2×1	2189	2.45	4.43	57.1	42.9	70.7	75.1	1.57
T7 2×2	2253	2.29	4.19	57.5	42.5	70.2	74.3	1.77
T8 2×3	2275	2.60	4.63	56.9	43.0	70.6	75.2	1.82
T9 2×4	2197	2.45	4.41	56.8	43.2	70.7	75.1	1.65
T10 2×5	2299	2.54	4.62	56.4	43.6	69.6	74.3	1.62
SEM[1]	69	0.11	0.12	0.89	0.89	0.52	0.52	0.21
Significance level	NS	NS	NS	NS	NS	NS	NS	NS

For each of the main factors, means having different superscripts in the same column are significantly different ($P \le 0.05$).
NS: not significant; *: significant at $P \le 0.05$. [1]: SEM= standard errors of the means.

Digestibility of nutrients:

Data in Table 5 show the effects of dietary plant protein level and enzyme supplementation and their interactions on the digestibility coefficients of nutrients of the experimental diets. In regard to the effect of dietary protein level on nutrient digestibility, birds fed the 20%CP-diets exhibited higher means of CP digestibility and N retention as compared to those fed the

18%CP-diets, being 94.58 and 93.25%, and 75.62 and 74.89% for CP and nitrogen retention, respectively.

In the present study, dietary enzyme supplementation produced significant improvements in digestibility coefficients of crude protein and ether extract as well as nitrogen retention compared with those of birds fed the unsupplemented diets. However, digestibility coefficients of DM, OM, CF and NFE, and ash retention were not affected by dietary enzyme supplementation. The interaction between the dietary protein level and enzyme supplementation had no significant effect on nutrient digestibility of the experimental diets (Table 5).

Table 5: Nutrient digestibility in broiler chicks fed experimental grower-finisher diets supplemented with different enzyme preparations.

Treatments	Digestibility coefficients (%)						N retention (%)	Ash retention (%)
	DM	OM	CP	EE	CF	NFE		
Protein level (A)								
1 18%	78.71	81.03	93.25^b	77.41	13.87	86.05	74.89^b	46.71
2 20%	78.76	81.11	94.58^a	78.07	13.34	85.64	75.62^a	46.13
SEM[1]	0.18	0.16	0.08	0.36	0.78	0.15	0.22	0.51
Significance level	NS	NS	**	NS	NS	NS	*	NS
Enzymes (B)								
1 Without	78.69	81.03	92.30^b	75.30^b	12.43	86.47	73.79^b	45.95
2 Phytase	78.32	80.66	94.21^a	78.10^a	13.39	85.28	75.20^a	45.88
3 Natuzyme	78.82	81.10	94.28^a	78.51^a	13.94	85.69	75.69^a	47.17
4 Sicozyme	78.82	81.23	94.43^a	78.80^a	13.87	85.84	75.63^a	45.87
5 Avizyme	79.03	81.33	94.34^a	78.01^a	14.37	85.93	75.97^a	47.22
SEM[1]	0.28	0.26	0.12	0.57	1.24	0.23	0.34	0.80
Significance level	NS	NS	**	**	NS	NS	**	NS
AB Interactions								
T1 1×1	78.48	80.87	91.48	74.25	12.76	86.68	72.93	45.64
T2 1×2	78.76	81.02	93.70	78.35	13.63	85.80	75.51	47.42
T3 1×3	78.80	81.06	93.64	77.96	13.69	85.91	75.35	47.66
T4 1×4	78.80	81.23	93.95	79.03	12.89	86.06	75.34	45.99
T5 1×5	78.71	81.00	93.47	77.47	16.36	85.79	75.30	46.83
T6 2×1	78.91	81.19	93.11	76.35	12.10	86.26	74.65	46.26
T7 2×2	77.89	80.31	94.71	77.85	13.17	84.75	74.89	44.34
T8 2×3	78.83	81.14	94.93	79.06	14.20	85.47	76.04	46.69
T9 2×4	78.84	81.24	94.92	78.57	14.85	85.62	75.92	45.75
T10 2×5	79.35	81.65	95.22	78.55	12.38	86.08	76.63	47.61
SEM[1]	0.40	0.37	0.17	0.81	1.75	0.33	0.48	1.13
Significance level	NS	NS	NS	NS	NS	NS	NS	NS

For each of the main factors, means having different superscripts in the same column are significantly different ($P \leq 0.05$).

NS: not significant; *: significant at $P \leq 0.05$; **: significant at $P \leq 0.01$. [1]: SEM= standard errors of the means.

The positive effects of dietary enzyme supplementation on apparent digestibility of CP and EE, and N retention, reported herein, are in partial agreement with the findings of Khan *et al.* (2006), who found that broiler chicks fed enzyme-supplemented diets exhibited higher means of apparent digestibility of DM, OM, CP and EE as compared to their control counterparts. In a recent study, Pourreza *et al.* (2007) reported that dietary enzyme supplementation had positive effects on protein and energy digestibility in broiler chicks.

In partial harmony with the present findings, Kocher *et al.* (2000) observed improved nutrient digestibility for high sunflower meal (SFM)-diets by broilers due to enzyme addition. In addition, Mandai *et al.* (2005) found a significant increase in the nitrogen-corrected apparent metabolizable energy (AME_n) values of SFM for chickens, guinea fowl and quails due to enzyme supplementation, while AME_n value of rapeseed meal was not improved by enzyme addition.

Concerning the mechanisms involved in the mode of action of exogenous enzymes, Myashkauskene *et al.* (1984) reported that the use of an enzyme in broiler feed caused greater proteolytic activity in the stomach and duodenum that ultimately improved digestibility of CP. According to Ritz *et al.* (1995), enzyme supplementation increased the length of villi within the jejunal and ileal sections of 3-week old turkey pullets fed corn-soybean meal diets. This increase in villi consequently results in an increase in epithelial surface area, and hence may improve nutrient digestibility and absorbability (Caspary, 1992). On the other hand, Zanella *et al* (1999) reported that supplementation of broiler diet with exogenous enzyme improved starch digestibility and consequently DM, OM, CP and energy digestibilities. They postulated that the solubilization and disruption of cell walls of grains endosperm by enzyme supplementation was primarily responsible for the improvement in digestibility.

Blood constituents:

Blood parameters (plasma levels of glucose, cholesterol, total protein and total lipids as well as activity of the enzymes: alkaline phosphatase, AST, and ALT in blood plasma) in broiler chicks fed the experimental diets are presented in Table 6. Analysis of Variance revealed no significant differences among the different dietary treatments in all blood parameters determined in this study. Thus, neither dietary crude protein level and enzyme preparations nor their interactions affected these blood parameters. It seams likely that the level of blood constituents in broiler chicks of the present study fell within the normal physiological range. In this connection, it is worth noting that similar concentrations of blood parameters in broiler chicks were reported by other workers (Raya, 1989; Raya and El-Shinnawy, 1989; Rabie *et al.,* 2002 and Raya *et al.* 2003), in spite of differences in their dietary treatments.

Economic efficiency:

Data in Table 6 show that economic efficiency was not affected in this study either by dietary protein level and enzyme supplementation or by their interactions.

Table 6: Blood parameters and economic efficiency of broiler chicks fed experimental grower-finisher diets supplemented with different enzyme preparations

Treatments	Glucose (mg/dL)	Cholesterol (mg/dL)	Total protein (g/dL)	Total lipids (g/dL)	Alkaline phosphatase (U/L)	AST (U/L)	ALT (U/L)	Economic efficiency (%)
Protein level (A)								
1 18%	229.2	114.3	3.43	0.655	52.1	125.2	45.8	104.2
2 20%	226.8	119.3	3.45	0.656	51.6	125.9	46.9	110.7
SEM[1]	1.74	1.84	0.05	0.01	1.17	1.21	1.03	2.4
Sign. level	NS	NS	NS	NS	NS	NS	NS	NS
Enzymes (B)								
1 Without	225.8	115.0	3.27	0.664	53.2	124.2	47.8	110.6
2 Phytase	231.6	115.6	3.45	0.645	51.8	126.6	46.0	105.5
3 Natuzyme	226.6	115.8	3.45	0.648	52.9	126.5	45.5	107.6
4 Sicozyme	228.3	119.3	3.53	0.660	49.9	125.3	46.3	106.9
5 Avizyme	227.6	118.3	3.49	0.661	51.6	125.3	46.2	106.7
SEM[1]	2.75	2.92	0.08	0.01	1.84	1.91	1.63	3.7
Sign. level	NS	NS	NS	NS	NS	NS	NS	NS
AB Interactions								
T1 1×1	221.8	110.4	3.37	0.662	54.8	124.0	49.3	102.0
T2 1×2	238.8	113.6	3.47	0.645	52.7	129.2	44.3	109.5
T3 1×3	228.2	115.5	3.40	0.647	52.8	127.7	43.3	102.4
T4 1×4	227.3	118.2	3.60	0.667	48.5	121.8	45.2	101.0
T5 1×5	229.7	114.0	3.30	0.657	51.8	123.3	46.8	106.1
T6 2×1	229.8	119.7	3.17	0.667	51.5	124.3	46.3	119.2
T7 2×2	224.3	117.6	3.43	0.645	50.8	124.0	47.7	101.6
T8 2×3	225.0	116.2	3.50	0.648	53.0	125.3	47.7	112.8
T9 2×4	229.2	120.5	3.47	0.653	51.3	128.7	47.5	112.8
T10 2×5	225.5	122.5	3.68	0.665	51.3	127.3	45.5	107.2
SEM[1]	3.89	4.12	0.11	0.01	2.61	2.70	2.31	5.3
Sign. level	NS	NS	NS	NS	NS	NS	NS	NS

NS: not significant. [1]: SEM= standard errors of the means.

CONCLUSION

From the previous results, it could be concluded that in these plant-protein experimental diets the level of 20% CP was more suitable for achieving a satisfactory growth performance of broiler chicks during the grower-finisher period. In addition, dietary enzyme supplementation, had some positive effect on chicks performance. Natuzyme and Sicozyme brought about the best results with the present experimental diets.

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الأداء الإنتـاجي لـدجاج اللحـم عنـد تغذيتـه علـي علائـق نباتيـة مـزودة بالإنزيمـات التجارية

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أجريت هذه الدراسة لمعرفة الأداء الإنتاجي لدجاج اللحم المغذي علي علائق نباتية متساوية في الطاقة (3170ك كالوري/كجم) وتحتوي علي 18% أو 20% بروتين خام وغير مزودة أو مزودة بأحد المستحضرات الإنزيمية التجارية وهي الفيتيز – الناتوزيم – السيكوزيم – الأفيزيم بمعدل نصف جم/كجم خلال فترة النمو من عمر 15 وحتى 42 يوم من العمر. تم تربية عدد 360 طائر عمر يوم من سلالة كوب-500 في بطاريات للحضانة حتي عمر أسبوعين غذيت علي العلف البادئ (طاقة قابلة للتمثيل 3000 ك كالوري/كجم وبروتين خام 21.57%) ثم نقلت في بطاريات الرعاية ووزعت لعشرة معاملات تجريبية متساوية (تجربة عاملية 2 ×5) بكل معاملة ثلاثة مكررات لتأكل كل معاملة أحد العلائق التجريبية وكانت الرعاية متماثلة لكل المعاملات. تم تسجيل أو حساب القياسات التالية: وزن الجسم، الزيادة الوزنية، استهلاك العلف، التحويل الغذائي، الكفاءة الاقتصادية، مواصفات الذبيحة، معاملات هضم العناصر الغذائية، بعض قياسات الدم (محتوي البلازما من الجلوكوز، البروتين، الدهون، الكولستيرول، ونشاط إنزيمات الفوسفاتيز القاعدي، الانين أمينوترانسفيريز، أسبرتيت أمينوترانسفيريز). ويمكن تلخيص أهم النتائج المتحصل عليها كالأتي: بغض النظر عن تأثير إنزيمات الغذاء، الطيور التي غذيت علي العلائق المحتوية علي 20% بروتين تفوقت معنويا في استهلاك الغذاء، الوزن النهائي، التحول الغذائي، النيتروجين المحتجز، معامل هضم البروتين بالمقارنة بالعلائق المحتوية علي 18% بروتين. بالنسبة لتأثير إنزيمات الغذاء: أظهرت العلائق المحتوية علي الإنزيمات تحسنا معنويا في كل من الوزن النهائي، معاملات هضم البروتين والدهن والنيتروجين المحتجز بالمقارنة بالعلائق الغير محتوية علي إنزيمات. بينما لم يؤثر مستوي بروتين العليقة أو إنزيمات الغذاء علي كل من الكفاءة الاقتصادية، مواصفات الذبيحة، مقاييس الدم. من النتائج السابقة يمكن استنتاج أنه في حالة تغذية دجاج التسمين علي علائق نباتية فإن مستوي البروتين المناسب في مرحلة النمو هو 20% بروتين خام للحصول علي الأداء الإنتاجي الجيد. علاوة علي ذلك اتضح أن لإنزيمات الغذاء نتائج إيجابية علي أداء دجاج اللحم. والمستحضرات الإنزيمية الناتوزيم و السيكوزيم حققت أفضل النتائج مع العلائق التجريبية المستخدمة في هذه الدراسة.