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EFFECT OF USING PROBIOTICS AND ENZYMES WITH PLANT-PROTEIN DIETS ON BROILER PERFORMANCE

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ABSTRACT

The present study was carried out to investigate the effect of using graded levels of Avian plus (probiotic) and Natuzyme (enzyme preparation) as feed additives with plant-protein diets on the performance of broiler chicks. Two hundred and fifty two Hubbard broiler chicks were randomly distributed to seven equal experimental groups of three replicates each. At the commencement, the chicks were fed a common starter diet (ME; 3000 kcal/kg and 21.57 % CP) up to 21 days of age; then, they were switched to the experimental grower diets from 22 to 42 days of age. Thus, seven isocaloric (ME of about 3150 kcal/kg)-isonitrogenous (about 19% CP) grower experimental diets were formulated: diet 1 (control), diets 2-4 contained three levels of the probiotic Avian plus (0.05, 0.10 and 0.15% of the diet) and diets 5-7 contained the same three levels of Natuzyme. All chicks were managed similarly and had free access to feed and water during both the starter and grower periods. The criteria of response were live body weight, weight gain, feed intake, feed conversion, economic efficiency of growth, carcass traits, nutrient digestibility [dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF) and nitrogen-free extract (NFE), and ash and N retention], and some blood plasma parameters [glucose, cholesterol, total protein, albumin and total lipids, as well as activity of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) in blood plasma].

For the whole experimental period, chicks fed the supplemented diets achieved significantly better means of feed conversion and economic efficiency of growth as compared to the control group. Birds fed the Natuzyme-supplemented diets consumed significantly more feed and exhibited superior final live body weight, weight gain, feed conversion and nutrient digestibility (DM, OM and NFE) as compared to those fed the Avian Plus-supplemented or control diets. Carcass traits and blood parameters of chicks were not significantly affected by dietary treatments. From the previous results, it can be concluded that dietary supplementation with Natuzyme or Avian plus can improve the growth performance of broiler chicks fed plant-protein diets during the growing period, but generally in Natuzyme's favor. Moreover, dietary supplementation with Natuzyme or Avian plus at a level of 0.10% had an advantage over the other two supplementary levels, in view of growth performance and economic efficiency.

Keywords: Natuzyme, Probiotics, broiler performance, carcass traits, blood parameters.

INTRODUCTION

In recent years, most poultry nutritionists and poultry producers, particularly those interested in broiler industry, tend to feed the birds on all-plant based diets. The primary problem of plant-derived feedstuffs is the presence of antinutritional compounds which can decrease absorption and utilization of nutrients and thus decreasing the performance of birds. On the other hand, the newly developed fast-growing strains of broiler chicks became more susceptible to nutritional and metabolic disorders and/or health problems, mainly because of the hyperphagia of birds and lack of using antibiotics in their diets. Adding exogenous enzymes and/or probiotics in diets of broiler chicks are currently used as a nutritional means for solving or counteracting such problems, thereby enhancing their health status and growth performance.

Probiotics are live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance, as defined by Fuller (1989). Currently, they have been used as a feed supplement in diets of different classes of poultry to enhance production performance and immune responses (Patterson and Burkholder, 2003; Huang *et al.*, 2004; Haghighi *et al.*, 2005; Higgins *et al.,* 2008). In this regard, probiotic supplementation to broiler diets had positive effects on body weight gain, feed conversion ratio, and mortality rate in broiler chickens (Jin *et al.*, 1996; Mohan *et al.*, 1996; Anjum *et al.*, 2005). Moreover, probiotics could protect broilers against pathogens by colonization in the gastrointestinal tract (Pascual *et al.*, 1999; Rolfe, 2000; Fuller, 2001).

Among the proposed mechanisms for the beneficial effects of probiotics are the following: (1) maintaining beneficial microflora in the gastrointestinal tract by inhibiting the growth of pathogenic microorganisms (Jin *et al*., 1996) and (2) increase the efficiency of nutrient utilization through improving the intestinal health resulting in higher activities of intestinal enzymes and nutrient availability (Nahashon *et al.,* 1994). Probiotics can also benefit the host animal by enhancing the synthesis of certain vitamins, providing digestive enzymes and increasing the production of volatile fatty acids that finally are metabolized in favor of the host (Fuller, 1989; Rolfe, 2000; Fuller, 2001). Probiotics may also increase the uptake of nutrients from the gastrointestinal tract through its indirect effect on its permeability (Mulder *et al.,* 1997).

The use of exogenous enzymes in poultry feeds to improve bird performance is not a new concept and had been extensively documented**.** Such improvements are related to greater digestion and absorption of nutrients in cereal grains caused by the degradation of cell wall non-starch polysaccharides (NSP) and releasing nutrients trapped within the cell and lowering digesta viscosity thereby enhancing nutrient digestion and subsequent absorption (Bedford and Schulze, 1998; Cowieson and Adeola, 2005). However, some investigators observed no positive effects of dietary enzyme supplementation for broilers (Perić *et al.,* 2002).

This study was carried out to investigate the effect of using graded levels of the probiotic (Avian plus) or the enzyme preparation (Natuzyme) with plant-protein diets on the performance of broiler chicks.

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:

Two hundred and fifty two, three-week-old Hubbard broiler chicks were randomly divided into seven equal experimental groups of three replications each, where each replicate group served as an experimental unit. These experimental chicks were raised in an open-sided house, equipped with conventional wire-floored brooding and rearing batteries. At the beginning, the chicks were kept in the brooding batteries and fed a starter diet (ME; 3000 kcal/kg and 21.57% CP) up to 21 days of age, then transferred to the rearing batteries and fed their respective experimental diets until the end of the experiment at 42 days of age. Seven isocaloric (ME of about 3150 kcal/kg)-isonitrogenous (about 19%CP) grower experimental diets were formulated: diet 1 (control), diets 2-4 contained three levels of the probiotic Avian plus (0.05, 0.10 and 0.15% of the diet) and diets 5-7 contained the same three levels (0.05, 0.10 and 0.15% of the diet) of enzyme preparation (Natuzyme). The experimental diets were formulated on the basis of the tabulated data of nutrient composition of feed ingredients published by NRC (1994). Composition and analysis of the experimental diets are presented in Table 1.

Performance of chicks:

The following criteria were used to assess the performance of broiler chicks during the whole experimental period (22-42 days of age): live body weight, weight gain, feed intake and feed conversion as well as total mortality and net profit per kg gain. Weekly records on individual body weights of chicks were maintained. Also, feed intake, weight gain and feed conversion were determined weekly on a replicate group basis. Mortality was 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 replications 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 6^{th} week of age, digestibility trials were conducted for evaluating the nutrient digestibility of the experimental diets. On the basis of average body weight, 6 birds were selected from each treatment, kept in a separate compartment of the battery fitted with galvanized metal trays for excreta collection, and fed their respective experimental diet for a preliminary period of three days, followed by a 3-day-test period during which excreta were quantitatively collected and feed consumption data were recorded. Samples of excreta were taken, immediately dried and kept for later analysis. The proximate analyses for the experimental diets and dried excreta were performed 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 of 2.62, as reported by Abou-Raya and Galal (1971). Digestibility coefficients of nutrients [dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF) and nitrogen free extract (NFE)] were calculated. Percentages of nitrogen and ash retention were also determined.

Table 1: Composition of the experimental diets containing the probiotics (Avian plus) or enzyme preparation (Natuzyme) fed to broiler chicks from 3 to 6 weeks of age

Ingredients (%)	control	Probiotic diets			Natuzyme diets		
	T1	T2	T3	T4	T5	T6	T7
Yellow corn	72.50	72.45	72.40	72.35	72.45	72.40	72.35
Soybean meal (44%)	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Corn gluten meal (62%)	13.40	13.40	13.40	13.40	13.40	13.40	13.40
Probiotic (Avian Plus)	0.00	0.05	0.10	0.15	0.00	0.00	0.00
Natuzyme	0.00	0.00	0.00	0.00	0.05	0.10	0.15
Dicalcium phosphate	2.30	2.30	2.30	2.30	2.30	2.30	2.30
Limestone	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Common salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Premix*	0.40	0.40	0.40	0.40	0.40	0.40	0.40
DL-Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10
L-Lysine-HCl	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Total	100	100	100	100	100	100	100
Cost per kg diet; P.T.	250.0	252.5	255.0	257.5	252.5	255.0	257.5
Calculated analysis (air dry basis; NRC 1994):							
ME; kcal/kg	3152	3151	3149	3147	3151	3149	3147
Crude protein; %	19.03	19.02	19.02	19.02	19.02	19.02	19.02
Ether extract; %	3.16	3.16	3.16	3.16	3.16	3.16	3.16
Crude fiber; %	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Ca; %	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Total P; %	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Non-phytate P; %	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Lysine; %	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Methionine; %	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Meth. & Cystine; %	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Determined analysis (dry matter basis; AOAC, 1990):							
Dry matter; %	90.37	90.33	90.35	90.35	90.35	90.22	90.35
Ash; %	6.52	6.50	6.53	6.52	6.53	6.54	6.53
CP; %	20.90	20.93	20.83	20.89	20.83	20.97	20.89
EE; %	3.46	3.44	3.45	3.46	3.45	3.48	3.49
CF; %	2.79	2.71	2.69	2.66	2.69	2.66	2.60
NFE; %	66.33	66.42	66.50	66.47	66.50	66.35	66.49

*** 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 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.**

Probiotic (Avian plus): contained *Lactobacillus acidophilus*, 90,000,000 CFU/kg; *Bifedobacteruim longhum*, 90,000,000 CFU/kg; *Bifedobacterium thermophilum*, 90,000,000 CFU/kg; *Enteroccus faecium*, 90,000,000 CFU/kg and *Lactobacillus planetarium*, 400,000,000 CFU/kg.

Natuzyme: contained Xylanase, 4,500,000 U/kg; Cellulase, 4,200,000 U/kg; Phytase, 200,000 U/kg; Alpha-amylase, 700,000 U/kg; Pectinase, 50,000 U/kg and Beta-glucanase, 500,000 U/kg.

Carcass traits:

At the end of the experiment (42 days of age), five birds per treatment were selected randomly and immediately sacrificed by decapitation. Then, their carcasses were scalded, feather-plucked and eviscerated. Procedures of cleaning out and excising of the abdominal fat pad were performed on hot carcasses. The abdominal fat pad (AF) included the adipose tissues surrounding the gizzard and the bursa of Fabricius and cloaca. Records on individual weights of eviscerated carcass (EC), front parts (FP) and hind parts (HP) of carcass, and edible organs, heart, liver without gall bladder (LI) and skinned empty gizzard, were maintained. Dressing percentage (DP) was calculated as eviscerated carcass plus giblets (GI). All measurements of carcass and its components were determined relative to live weight at slaughter.

Blood parameters:

At 42 days of age, five blood samples per treatment were collected in heparinized tubes by puncturing the wing veins of birds. Then, plasma were 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 glucose, cholesterol, total protein, albumin and total lipids as well as plasma activity of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) according to the methods of Trinder (1969), Allain *et al.* (1974), Henry (1964), Doumas *et al*. (1971), Frings and Dunn (1970) and Reitman and Frankel (1957), respectively.

Statistical analyses:

Data were statistically processed using Quattro Program software (Borland International, 1990). The statistical analysis was performed by one-way analysis of variance using the Statgraphics Program software (Rockville, 1991). Significant differences among treatments of the different variables were identified at $P \leq 0.05$ by LSD-multiple range test.

RESULTS AND DISCUSSION

Performance of chicks:

Data of the performance of broiler chicks (live body weight, weight gain, feed intake and feed conversion) fed the probiotic (Avian plus) or enzyme preparation (Natuzyme)-supplemented diets are presented in Tables 2 and 3. There were significant differences in final live body weight and body weight gain of chicks during the periods of 4-5, 5-6 and 3-6 weeks of age among the different dietary treatments. Birds fed the Natuzyme-supplemented diets at any inclusion rate, or 0.15%-Avian plus diets achieved significantly higher final live body weight (LBW) and superior body weight gains (BWG) during the whole experimental period (Table 2) as compared to the control group. The differences in feed intake were significant among treatments during the periods of 4-5 and 3-6 weeks of age. Generally, birds fed the Natuzyme-supplemented diets; in particular that with 0.15% supplemental level, consumed more feed as compared to those of chicks fed the Avian plus-supplemented or control diets (Table 3). Significant differences were detected in feed conversion during the periods of 3-4, 5-6 and 3-6 weeks of age. Birds fed Avian plus or Natuzyme-supplemented diets, whatever was the supplemental level, exhibited a significantly improved feed conversion as compared to that of birds fed the control diet. As for the whole experimental period, even though the differences in feed conversion were erratic, birds fed diets containing Natuzyme or Avian plus at a level of 0.1% attained the best feed conversion (Table 3).

Table 2: Live body weight and weight gain of broiler chicks fed the probiotic (Avian plus) or enzyme preparation (Natuzyme)-supplemented diets (means ± SE)

Treatments	Weekly LBW (g)				Weekly BWG (g)			
	3	4	5	6	3-4	4-5	5-6	3-6
T1 control	590 ± 6.1	942 ± 21	1416 ± 26	1857^{c} ± 38	353 ± 16	474^{bc} ± 6	441^{b} ±12	1268^{e} ±34
T2 (Avian plus 0.05%)	591 ± 1.1	969 ± 16	1425 ± 37	1929^{bc} ± 50	379 ± 14	456^{bc} ± 22	504^{ab} ±15	1338^{de} ±49
T3 (Avian plus 0.10%)	594 ± 5.0	982 ± 11	1423 ± 25	1938^{bc} ± 19	388 ± 16	441^{c} ± 18	515^{a} ±29	1344^{cde} ±17
T4 (Avian plus 0.15%)	596 ± 3.6	978 ± 17	1419 ± 12	1970^{ab} ± 17	382 ± 20	441^{c} ± 6	552^{a} ±26	1374^{bcd} ±16
T5 (Natuzyme 0.05%)	592 ± 4.8	969 ± 14	1506 ± 9	2026^{a} ± 27	377 ± 10	537^{a} ± 23	520^{a} ±35	1434^{ab} ±24
T6 (Natuzyme 0.10%)	586 ± 1.2	984 ± 8	1480 ± 14	2048^{a} ± 3	399 ± 8	496^{ab} ± 6	568^{a} ±12	1463^{a} ±5
T7 (Natuzyme 0.15%)	588 ± 4.5	973 ± 22	1459 ± 27	2010^{ab} ± 7	385 ± 21	487^{b} ± 8	550^{a} ±27	1422^{abc} ±11
Significance levels	NS	NS	NS	**	NS	**	*	**

$^{a-e}$: Means having different superscripts in the same column are significantly different (P≤0.05).
NS: Not significant; *: Significant at P≤0.05; **: Significant at P≤0.01.

Feed conversion is a growth and feed intake-correlated trait. Therefore, the better growth performance (LBW and BWG, Table 2) of broilers fed the Natuzyme-supplemented diets, reported herein, are mainly related to increasing feed intake (Table 3) and improved digestibility of nutrients (Table 5). This enzyme preparation contained activity of multi-enzymes (xylanase, cellulase, phytase, α-amylase, pectinase and β-glucanase) which might function synergistically.

In general, the improved growth performance of broilers fed Natuzyme-supplemented diets in the present study is in harmony with the results of Khan *et al.* (2006), who investigated the response of broiler chicks to diets supplemented with two fungal enzyme preparations and found that birds fed the supplemented diets consumed more feed and grew faster and had better feed conversion compared with those of the control group. Similarly, Lázaro *et al.* (2003) studied the influence of enzyme supplementation (containing *β*-glucanase and xylanase) to rye-based diets on broiler performance. They found that enzyme supplementation improved feed intake, daily gain, and feed conversion of birds from 4 to 25 days of age. In addition, Garcia *et al.* (2003) reported that supplementation of a corn-soybean meal diet with α-amylase had positive effects on feed intake, body weight gain and feed conversion of broilers at the end of a 42-day trial. Moreover, Yu and Chung (2004) investigated the effects of using multi-enzyme mixtures (containing α-amylase, β-glucanase and xylanase) on the growth performance of broilers fed corn-soybean meal diets with a reduced energy (3% reduction in dietary ME) and found that dietary enzyme supplementation allowed full restoration of growth performance of broilers comparable to those fed the adequate energy control diet. On the other hand, the positive effects of feeding the diets containing 0.05%, 0.10% and 0.15% feed additive on growth performance (LBW, BWG and feed conversion), observed in the present study, are an indication that addition of both supplements proved to be effective whatever was the added level**.**

Table 3: Feed intake and feed conversion of broiler chicks fed the probiotic (Avian plus) or enzyme preparation (Natuzyme)-supplemented diets (means ± SE)

Treatments	Weekly feed intake/bird (g)				Weekly feed conversion (feed : gain)			
	3-4	4-5	5-6	3-6	3-4	4-5	5-6	3-6
T1 control	699 ± 8	875[b] ± 29	1001 ± 20	2575[bcd] ± 54	1.987[a] ± 0.07	1.844 ± 0.04	2.273[a] ± 0.02	2.032[a] ± 0.01
T2 (Avian plus 0.05%)	656 ± 18	808[d] ± 3	1031 ± 34	2495[cd] ± 49	1.733[b] ± 0.03	1.781 ± 0.08	2.046[b] ± 0.01	1.867[bc] ± 0.03
T3 (Avian plus 0.10%)	666 ± 14	789[d] ± 28	1010 ± 56	2465[d] ± 53	1.722[b] ± 0.05	1.789 ± 0.04	1.962[b] ± 0.01	1.834[cd] ± 0.03
T4 (Avian plus 0.15%)	670 ± 19	818[cd] ± 5	1079 ± 25	2567[bcd] ± 12	1.761[b] ± 0.05	1.855 ± 0.02	1.962[b] ± 0.06	1.869[bc] ± 0.01
T5 (Natuzyme 0.05%)	679 ± 7	931[a] ± 11	1028 ± 41	2638[ab] ± 41	1.803[b] ± 0.05	1.739 ± 0.07	1.986[b] ± 0.07	1.840[bcd] ± 0.01
T6 (Natuzyme 0.10%)	676 ± 11	859[bc] ± 4	1077 ± 23	2612[abc] ± 18	1.695[b] ± 0.01	1.734 ± 0.03	1.896[b] ± 0.01	1.786[d] ± 0.01
T7 (Natuzyme 0.15%)	688 ± 18	902[ab] ± 5	1103 ± 5	2692[a] ± 11	1.794[b] ± 0.08	1.854 ± 0.03	2.014[b] ± 0.09	1.894[b] ± 0.04
Significance levels	NS	**	NS	*	*	NS	**	**

[a-d]: Means having different superscripts in the same column are significantly different (P≤0.05).
NS: Not significant; *: Significant at P≤0.05; **: Significant at P≤0.01

Carcass traits:

The results of carcass traits of 42-day-old broiler chicks fed the probiotic (Avian plus) or enzyme preparation (Natuzyme)-supplemented diets are presented in Table 4. Neither type nor level of feed additive gave significant differences in carcass traits of chicks. The insignificant increase in AF of broilers fed diets containing 0.05, 0.10 and 0.15% feed additive may in part be related to differences in final LBW and feed intake of these experimental groups of birds. Alternatively, the better feed conversion due to the effect of supplemental feed additive (Table 3) attributable to improved nutrient digestibility (Table 5) may account for an increase in efficiency of dietary energy utilization and its portion deposited as body fat.

In line with the present results, Sherif (2009) found that dietary enzyme supplementation had no significant effect on carcass traits of broiler chicks. The lack of significant differences in dressing percentage of broilers in response to feeding the probiotic-supplemented diets in the present study is in accordance with the results obtained by Anjum *et al.* (2005) with broiler chicks, and by Sahin *et al.* (2008) with growing quails. Also, the insignificant differences in carcass traits of broilers in response to dietary Natuzyme supplementation, observed herein, are in agreement with the findings of Khan *et al.* (2006). However, Alam *et al.* (2003) observed that carcass yield of broilers increased by feeding enzyme-supplemented diets.

Table 4: Carcass traits[§] of 6-week-old broiler chicks fed the probiotic (Avian plus) or enzyme preparation (Natuzyme)-supplemented diets (means ± SE)

Treatments	LBW (g)	LI (%)	GI (%)	FP (%)	HP (%)	EC (%)	DP (%)	AF (%)
T1 control	2004 ± 41	2.37 ± 0.13	4.48 ± 0.11	40.43 ± 0.7	30.64 ± 0.5	71.07 ± 0.3	75.55 ± 0.4	1.18 ± 0.15
T2 (Avian plus 0.05%)	1994 ± 62	2.15 ± 0.09	4.28 ± 0.08	39.91 ± 0.3	30.81 ± 0.4	70.72 ± 0.4	75.00 ± 0.4	1.68 ± 0.23
T3 (Avian plus 0.10%)	1936 ± 46	2.16 ± 0.03	4.19 ± 0.06	41.33 ± 0.2	30.17 ± 0.4	71.50 ± 0.3	75.69 ± 0.3	1.81 ± 0.04
T4 (Avian plus 0.15%)	2024 ± 34	2.18 ± 0.06	4.28 ± 0.11	39.78 ± 0.7	30.96 ± 0.7	70.74 ± 0.3	75.03 ± 0.3	1.54 ± 0.22
T5 (Natuzyme 0.05%)	1950 ± 29	2.20 ± 0.13	4.53 ± 0.12	39.23 ± 0.9	31.53 ± 0.7	70.76 ± 0.4	75.28 ± 0.5	1.58 ± 0.29
T6 (Natuzyme 0.10%)	1984 ± 41	2.18 ± 0.04	4.37 ± 0.05	40.45 ± 0.4	30.40 ± 0.1	70.85 ± 0.4	75.21 ± 0.3	1.49 ± 0.24
T7 (Natuzyme 0.15%)	1968 ± 35	2.04 ± 0.09	4.10 ± 0.05	40.92 ± 0.4	30.20 ± 0.3	71.12 ± 0.2	75.22 ± 0.2	1.60 ± 0.09
Significance levels	NS	NS	NS	NS	NS	NS	NS	NS

[§]: LI, GI, FP, HP, EC, DP and AF are relative weights of liver, giblets, front parts, hind parts, eviscerated carcass, dressed carcass and abdominal fat pad (% of live body weight; LBW), respectively.
NS: Not significant.

Digestibility of nutrients:

Data presented in Table 5 illustrate means of nutrient digestibility of broiler chicks as influenced by feeding the probiotic (Avian plus) or enzyme preparation (Natuzyme)-supplemented diets. The differences among treatments in nutrient digestibility were significant for DM, OM, CP, EE, NFE and N retention but CF digestibility and ash retention were not affected significantly. Broilers fed the Natuzyme-supplemented diets (T5, T6 and T7) exhibited significantly higher means of nutrient digestibility (DM, OM, and NFE) compared with those of birds fed the Avian plus-supplemented or control diets (Table 5). Apart from the type and level of feed additive, birds fed the supplemented diets exhibited higher means of digestibility for CP, EE and N retention as compared to those of the control group (Table 5).

The improved digestibility of DM, OM and NFE in broilers fed the Natuzyme-supplemented diets of the present study is in harmony with the results of Khan *et al.* (2006), who found that dietary enzyme supplementation improved apparent digestibility of DM, OM, CP, EE and starch. Similar response was observed by Santos *et al.* (2008), who reported that feed intake and nutrient digestibility were increased by supplementation of broiler diets with phytase during the periods of 14-21 and 24-35 days of age.

According to the scientific literature, addition of a mixture of amylase, protease, and xylanase could benefit the broiler chicks fed diets based on corn and soybean meal, assuming that young birds might be deficient in certain endogenous enzymes (Zanella *et al.*, 1999; Douglas *et al.*, 2000; Café *et al.*, 2002). In addition, Garcia *et al.* (2003) observed a pronounced improvement in metabolizable energy and digestibility of OM and starch in 7- and 28-day old broiler chicks in response to α-amylase supplementation, indicating that the supplementation with this enzyme might be beneficial in the growing period even when the digestive system of the bird is assumed to be totally developed. On the other hand, Ritz *et al.* (1995) reported that dietary *α*-amylase supplementation increased the length of the villi within the jejunal and ileal sections of 3-week-old turkey poults fed corn-soybean meal diets. This increase in villi length consequently results in an increase in epithelial surface area, and hence may improve nutrient digestibility and absorbability (Caspary, 1992).

Table 5: Nutrients digestibility of broiler chicks fed the probiotic (Avian plus) or enzyme preparation (Natuzyme)-supplemented diets (means ± SE)

Treatments	Digestibility coefficients (%)						Retention (%)	
	DM	OM	CP	EE	CF	NFE	N	Ash
T1 control	77.22^{b} ± 0.7	79.41^{b} ± 0.6	92.82^{d} ± 0.2	77.97^{cd} ± 1.0	15.50 ± 2.4	84.19^{b} ± 0.5	75.09^{d} ± 0.8	39.14 ± 1.7
T2 (Avian plus 0.05%)	75.67^{c} ± 0.5	77.73^{c} ± 0.4	93.90^{c} ± 0.2	77.69^{d} ± 1.2	15.58 ± 3.2	81.59^{d} ± 0.3	76.55^{cd} ± 0.4	36.38 ± 1.5
T3 (Avian plus 0.10%)	76.99^{b} ± 0.2	79.03^{b} ± 0.3	94.27^{c} ± 0.1	80.62^{bc} ± 1.0	13.37 ± 2.1	82.86^{cd} ± 0.4	77.85^{bc} ± 0.2	38.82 ± 0.7
T4 (Avian plus 0.15%)	77.94^{b} ± 0.2	79.99^{b} ± 0.2	95.49^{b} ± 0.1	83.20^{ab} ± 0.7	16.36 ± 1.5	83.08^{bc} ± 0.2	80.87^{a} ± 0.2	38.48 ± 0.2
T5 (Natuzyme 0.05%)	80.26^{a} ± 0.4	82.76^{a} ± 0.5	95.10^{b} ± 0.1	79.54^{cd} ± 0.7	20.49 ± 2.1	86.98^{a} ± 0.7	79.05^{b} ± 0.8	40.29 ± 1.0
T6 (Natuzyme 0.10%)	80.09^{a} ± 0.3	82.50^{a} ± 0.3	95.16^{b} ± 0.2	83.57^{a} ± 0.7	17.70 ± 0.7	86.21^{a} ± 0.3	81.05^{a} ± 0.4	38.37 ± 0.5
T7 (Natuzyme 0.15%)	80.22^{a} ± 0.4	82.73^{a} ± 0.3	95.98^{a} ± 0.1	84.91^{a} ± 1.1	19.17 ± 2.8	86.06^{a} ± 0.4	81.67^{a} ± 0.5	37.97 ± 1.4
Significance levels	**	**	**	**	NS	**	**	NS

a-d: Means having different superscripts in the same column are significantly different (P≤0.05). NS: Not significant; *: Significant at P≤0.05; **: Significant at P≤0.01

Blood parameters and economic efficiency:

Blood plasma parameters [levels of glucose (GL), cholesterol (CH), total protein (TP), albumin (AL) and total lipids (TL)] as well as activity of the enzymes AST and ALT in blood plasma, and economic efficiency of growth (EEG) of broiler chicks fed the probiotic (Avian plus)- or enzyme preparation (Natuzyme)-supplemented diets are given in Table 6.

Neither type nor level of feed additive exerted a significant effect on blood plasma parameters, measured herein. In line with the present results, Sahin *et al.* (2008) reported that dietary supplementation with probiotic and prebiotic combination had no effect on serum biochemical parameters (glucose, total protein, albumin, total cholesterol and triglycerides) of 34-day-old growing Japanese quails. Similar results were obtained by Sherif (2009) who observed no significant effect of dietary supplementation with exogenous enzymes on blood parameters of broiler chicks. In general, levels of blood parameters of broiler chicks, observed herein, are comparable to those reported by other workers (Rabie *et al.,* 2002; Raya *et al.,* 2003), regardless of differences in their dietary treatments.

Table 6: Some blood parameters§ and economic efficiency of broiler chicks fed the probiotic (Avian plus) or enzyme preparation (Natuzyme)-supplemented diets (means ± SE)

Treatments	GL	CH	TP	AL	TL	AST	ALT	EEG§
	(mg/dL)		(g/dL)			(U/L)		(%)
T1 control	216 ± 8	109 ± 3	3.26 ± 0.3	1.52 ± 0.11	0.652 ± 0.01	115 ± 1.7	49.2 ± 2.9	97.0[e] ± 1.1
T2 (Avian plus 0.05%)	203 ±18	109 ± 4	3.30 ± 0.3	1.50 ± 0.09	0.650 ± 0.01	119 ± 3.1	45.6 ± 2.7	112[bc] ± 3.6
T3 (Avian plus 0.10%)	232 ± 3	110 ± 4	3.14 ± 0.1	1.56 ± 0.09	0.656 ± 0.02	120 ± 2.5	48.6 ± 3.6	114[abc] ± 3.1
T4 (Avian plus 0.15%)	228 ± 5	114 ± 2	3.68 ± 0.2	1.54 ± 0.09	0.640 ± 0.02	114 ± 2.4	46.2 ± 3.7	108[cd] ± 1.6
T5 (Natuzyme 0.05%)	226 ± 7	117 ± 2	3.18 ± 01	1.44 ± 0.09	0.632 ± 0.01	118 ± 2.1	49.6 ± 4.7	115[ab] ± 0.4
T6 (Natuzyme 0.10%)	225 ± 6	113 ± 6	3.24 ± 0.3	1.38 ± 0.09	0.638 ± 0.03	118 ± 3.0	45.4 ± 2.6	120[a] ± 1.3
T7 (Natuzyme 0.15%)	226 ± 6	115 ± 4	3.12 ± 0.3	1.48 ± 0.10	0.618 ± 0.01	115 ± 2.9	47.0 ± 3.0	105[d] ± 2.2
Significance levels	NS	NS	NS	NS	NS	NS	NS	**

§: GL, CH, TP, AL, TL, ALT and AST are blood plasma levels of glucose, cholesterol, total protein, albumin and total lipids, and activity of alanine aminotransferase and aspartate aminotransferase in blood plasma; EEG is economic efficiency of growth.

a-c: Means having different superscripts in the same column are significantly different (P≤0.05).

NS: Not significant; **: Significant at P≤0.01

As for the economic efficiency, it was observed that birds fed the supplemented diets significantly surpassed their control counterparts in EEG. The best mean of EEG was achieved by birds fed the diet containing 0.1% Natuzyme, followed by those attained by chicks fed the diets containing 0.05% Natuzyme, 0.1%, 0.05%, 0.15% Avian plus, 0.15% Natuzyme and the control diet in a descending order, respectively.

Conclusion

From the previous results, it can be concluded that dietary supplementation with Natuzyme or Avian plus can improve the growth performance of broiler chicks fed plant-protein diets during the growing period, but generally in Natuzyme's favor. Moreover dietary supplementation with Natuzyme or Avian plus at a level of 0.10% (of the diet) had an advantage over the other two supplementary levels, in view of growth performance and economic efficiency.

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تــأثير اســتخدام المنشــطات الحيويــة والإنزيمــات مــع العلائــق النباتيــة علــي الأداء الإنتاجي لدجاج اللحم

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أجريت هذه التجربة لمعرفة تأثير استخدام مستويات متدرجة من المنشط الحيوي (Avian plus) والمستحضر الإنزيمي (Natuzyme) مع العلائق النباتية علي الأداء الإنتاجي لدجاج اللحم. تم توزيع عدد ٢٥٢ كتكوتا هبرد عشوائيا إلي سبعة مجموعات تجريبية متساوية بكل منها ثلاثة مكررات. غذيت الطيور علي العليقة البادئة (٣٠٠٠ ك كالوري/كجم وبروتين خام ٢١,٥٧%) حتى عمر ٢١ يوما ثم بدأت التغذية علي العلائق التجريبية من اليوم ٢٢ وحتى عمر ٤٢ يوما، لذلك تم تكوين سبعة علائق تجريبية متساوية في البروتين الخام (١٩%) والطاقة القابلة للتمثيل (٣١٥٠ ك كالوري/كجم): العليقة الأولي (الكنترول)، العلائق من ٢-٤ احتوت علي ثلاث مستويات من المنشط الحيوي (٠,٠٥، ٠,١، ٠,١٥% من العليقة)، والعلائق من ٥-٧ احتوت علي نفس الثلاث مستويات من المستحضر الانزيمي. وكانت التغذية بحرية وظروف الرعاية متماثلة لكل المعاملات التجريبية طوال فترة التربية. تم أخذ القياسات التالية: وزن الجسم، الزيادة الوزنية، استهلاك العلف، التحويل الغذائي، الكفاءة الاقتصادية للنمو، مواصفات الذبيحة، معاملات هضم العناصر الغذائية (المادة الجافة، المادة العضوية، البروتين الخام، الدهن الخام، الألياف الخام، والمستخلص خالي الأزوت، و% المحتجز من الرماد والنيتروجين)، بعض قياسات الدم (محتوي البلازما من الجلوكوز، الكولستيرول، البروتين الكلي، الألبيومين، الدهون الكلية، ونشاط إنزيمي ألانين أمينوترانسفيريز و أسبرتيت أمينوترانسفيريز). ويمكن تلخيص أهم النتائج المتحصل عليها كالأتي: حققت الطيور المغذاة علي العلائق المحتوية علي المستحضر الإنزيمي أو المنشط الحيوي متوسطات أفضل معنويا لكل من معامل التحويل الغذائي والكفاءة الاقتصادية للنمو بالمقارنة بالطيور التي غذيت علي العليقة الكنترول. التغذية علي العلائق المدعمة بالمستحضر الإنزيمي أدت إلي زيادة معنوية في استهلاك الغذاء والوزن الحي النهائي والزيادة في وزن الجسم ومعامل التحويل الغذائي ومعاملات هضم المادة الجافة والمادة العضوية والمستخلص الخالي من الأزوت وذلك بالمقارنة بالمجموعات التجريبية الأخرى التي غذيت علي العلائق المدعمة بالمنشط الحيوي أو عليقة الكنترول. لم تتأثر صفات الذبيحة ومكونات الدم المدروسة بالتغذية علي العلائق التجريبية المختلفة. من النتائج المتحصل عليها يمكن استنتاج أن المستحضر الإنزيمي أو المنشط الحيوي المستخدم في هذه الدراسة يمكن أن يحسن الأداء الإنتاجي لكتاكيت اللحم المغذاة علي العلائق النباتية أثناء فترة النمو، مع أفضلية المستحضر الإنزيمي إلي حد ما. وبالنظر إلي الأداء الإنتاجي والناحية الاقتصادية لوحظ أن استخدام المستحضر الإنزيمي أو المنشط الحيوي بمستوي ٠,١% من العليقة أفضل من باقي مستويات الإضافة.