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Effect of Phytase Enzyme Supplementation of Maize Based Broiler Diets on Growth Performance, Availability of Minerals and Economic Benefits

Halima Hassen[1] and S.S. Chauhan[2]

[1]Andassa Livestock Research Center, P. O. Box 27, Bahir Dar, Ethiopia

[2]Animal Nutrition, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar 263 145, Uttarranchal, India

Abstract

A study was conducted to evaluate the role of phytase-2500 enzyme on growth performance; ash percentage, calcium and phosphorus contents of toe and tibia bones; and on the economic benefits of its addition to a maize based broiler chicken diets. Seventy-two New Hampshire broiler chicks were used and distributed randomly into four different treatment groups using a Completely Randomized Design (CRD), with three replicates of six chicks each. Phytase enzyme at the levels of 0(T_1), 200 (T_2), 400 (T_3) and 600 (T_4) Units/kg diet were added. The supplementation of broiler diet with phytase enzyme significantly improved body weight gain (905.87 to 1078.51 gm), reduced average feed intake (2656.99 to 2021.53 gm) and improved the feed conversion efficiency (2.94 to 1.87). Phytase enzyme addition significantly improved the ash, calcium and phosphorus contents in the toe and tibia bones, and increased the net profit to Rs. 13.59 (T3)

Key words: Bone minerals, enzyme, maize diet, performance, Poultry, profit

Introduction

About two-third of the phosphorus in poultry feeds of plant origin is found as phytate-phosphorus, which has low availability to simple-stomached animals. Phytate is a compound that occurs naturally in many foods derived from plants (Paul and Soutugate, 1978; Maga, 1982). There are anti-nutritional factors that hinder the availability, digestibility, absorption and utilization of nutrients in poultry feeds. These have depressive effects on the digestion of protein, carbohydrate, and in the utilization of minerals and vitamins. Of these, phytic acid is ubiquitous in plant-derived feeds in the form of phytate (Lange *et al.,* 2000).

Phytate has been recognized as a toxic nutrient because it binds various essential metals and also reduces their availability for absorption in the diet of monogastric animals, which lack endogenous phytase enzyme. The pretreatment of poultry feeds with exogenous enzymes would increase the bioavailability of the chelated nutrients and improve the nutritional value of the diet (Bedford, 2000). This investigation was initiated to evaluate the effect of phytase enzyme on growth performance of broilers, availability of minerals in toe and tibia bones, and to determine the economic benefits in adding phytase in broiler diets.

Materials and Methods

Study site

The investigation was conducted at the Poultry Research Center (PRC) of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttaranchal during the period 17th January 2002 to 11th March 2002.

Procurement of chicks and their management

A total of seventy-two, New Hampshire broiler chicks were obtained from the Poultry Research Center. The chicks were wing band numbered, individually weighed and distributed randomly into twelve pens with of six chicks each. The chicks were kept on raised wire mesh floors in the brooder house, and had free access to light. Feed and water were given *ad libitum* throughout the experimental period. Individual body weight and feed consumption were recorded on weekly basis for chicks in each pen.

Preparation of experimental diets

The broiler starter feed (Table 1) was purchased from Uttar Pradesh Agro Industrial Corporation, Moradabad. Phytase-2500 enzyme, which was procured from Varsha multi tech, Bangalore was added at the levels of 0 (T1), 200 (T2), 400 (T3) and 600 (T4) Units (U) per kg of the diet and uniformly mixed. The experiment was executed in a Completely Randomized Design (CRD) with three replications comprising of four phytase levels. A unit of phytase is defined as the quantity of enzyme that releases 1 μmol of inorganic orthophosphate per min. from 5.1 mM sodium phytate at pH 5.5 and 37 ^{o}C (Engelen *et al*., 1994).

Sampling of bones for analysis

Twelve birds, three from each treatment were picked randomly at the end of the experimental period and killed by cutting the whole neck. The left and right tibia bones of the birds were collected, separately. The toes samples of the killed birds from both legs were obtained by severing the middle toes through the joint between the second and third tarsal bones from the distal end were collected, separately, yielding two samples of toes per pen. The samples of toes were dried to constant weight at 100°C and then ashed in a muffle furnace at 600°C for 4 hrs. The tibia samples, after oven-drying, were cleaned from all adhering soft tissue. The bone samples were then extracted for about 8 hrs in a soxhlet apparatus using petroleum ether, and ashed at 600°C for 4 hrs in a muffle furnace. The ash obtained was solubilized with hydrochloric acid (1:1, V/V) and made up to volume in a 100ml volumetric flask using distilled water.

Table 1. The composition of the experimental diet *

Ingredients	Percent
Maize	42
Deoiled soybean meal	22
Deoiled rice bran	12
Rice polish	10
Jwala fish	7
Mineral mixture	1
Lime stone	3
Molasses	3
Total	100

*- Feed additives provided per 100kg diet: Vitamin AB2D3K, 10 gm; Vitamin B- complex, 20 g Neftin-200, 50 gm; other vitamins, 200 gm; Check 'O' Tox, 200 gm; Liveroline, 100 gm and Meridot, 50 gm.

Chemical analysis

Representative samples for the determination of the dry matter and crude protein contents of poultry feeds and their excreta were taken and analyzed according to AOAC (1990) procedures. Acid insoluble ash determinations were performed after ashing the samples and treating the ash with hydrochloric acid (1:1, V/V) (Gupta et al., 1992). Phosphorus was analyzed calorimetrically after digestion of the sample with hydrochloric acid according to the method of Gupta et al. (1992). Gross energy was determined using the chromic oxide method (O'Shea and Maguir, 1962), phytate-phosphorus content (Haugh and Lantzsch, 1983) and calcium with the help of GBC Avanta 1.33 version Atomic Absorption Spectrophotometer.

Statistical analysis

The experiment was conducted in Completely Randomized Design (CRD) with four treatments comprising four phytase levels each replicated three times. The data obtained was statistically analyzed using MSTAT-C computer software (1989). Significance of mean differences was tested using (Duncan,

1955) The Duncan's multiple range test. partial budgeting was used to analyze the benefits of phytase supplementation on the maize based broiler diets.

Results and Discussion

Body weight gain

The effects of various levels of supplementation of phytase enzyme on body weight gain of broilers at the end of seven weeks of the experimental period are presented in Table 2. There were significant differences between the treatment groups due to the addition of various levels of phytase enzyme. Treatment 3 (T_3), which had 400 U of phytase/kg of the diet, had highest weight gain (1078.51 gm). These values were significantly ($P<0.01$) higher than all other treatments; T_2 showed the second highest value (1021.32 gm) followed by T_4 (959.66 gm). Treatment 1 (where no phytase was added) showed the lowest weight gain value (905.87 gm). There was an increase in mobilization of nutrients due to phytase enzyme supplementation.

Phytase-2500 enzyme exerted growth promoting effect on broiler chicks at 400 U of phytase added in the ration. In contrast Arun and Dewgoda (1997) reported non-significant differences in live weight gains in broiler chickens due to enzyme supplementation. These findings are in agreement with previous work by Cabahug *et al.* (1999), who observed that there were little benefits in performance responses due to the addition of phytase enzyme beyond 400 FTU per kg diet. On the other hand, Kornegay *et al.* (1996) found that on maize soybean meal and semi purified soybean meal diets where responses to phytase enzyme reached a plateau were 600 to 700 FTU/kg diet.

Feed intake

The supplementation of phytase enzyme in maize based broiler diet showed an effect on feed intake (Table 2). At all age group birds in T_1 consumed the highest amount of feed followed by T_2, T_4 and T_3. The values differed significantly ($P<0.01$) among each other. Feed intake was least for birds in T_3 (2021.53 gm) followed by those in T_4 (2076.61 gm), T_2 (2339.53 gm) and T_1 (2656.99 gm). Yi *et al.* (1996) indicated that the addition of supplemental phytase at the levels 350, 700, 1050 U/kg of soybean or corn meal increased feed intake from 6 to 25 %.

Feed efficiency

The calculated values of feed conversion efficiency (feed: gain) of broilers in this experiment are presented in Table 2. The best-feed conversion efficiency was recorded in T_3 throughout the experiment. This treatment had 400 U of phytase/kg of diet. The values of feed efficiency also showed significant (P<0.01) differences between the treatments. The values of feed efficiency were noted as 2.94 (T_1), 2.30 (T_2), 1.87 (T_3) and 2.17 (T_4). Supplementing piglet diets with 1500 U phytase activity per kg feed significantly improved the feed conversion efficiency from 1.65 to 1.52 (Jongbloed et al., 1993).

Mortality

No mortality was recorded in broiler chicks consuming diets supplemented with 200 U (T_2) and 600 U (T_4) of phytase enzyme. However, the mortality was higher in birds under the control and 400 U of phytase supplemented diets. A mortality of 5.56 and 16.67% was recorded for the control, and 400 U phytase fed broilers, respectively.

Table 2**.** Effect of varying levels of supplemental phytase enzyme on broiler performance at the end of the seventh week

Phytase level (U/kg diet)	Body weight gain (gm/bird)	Feed intake (gm/bird)	Feed conversion efficiency
0	905.87^{d}	2656.99^{a}	2.94^{a}
200	1021.32^{b}	2339.51^{b}	2.30^{b}
400	1078.51^{a}	2021.53^{d}	1.87^{d}
600	959.66^{c}	2076.61^{c}	2.17^{c}
Mean	991.34	2273.66	2.32
SEM±	2.89	2.27	0.02
LSD	15.13^{**}	11.89^{**}	0.09^{**}

Values with different superscript within a column differ significantly at 1 %(**), 5 %(*)

Toe mineral contents

Ash, calcium and phosphorus contents of left and right toes of broiler chicks fed on supplemental phytase are summarized in Tables 3. The levels of supplemental phytase affected the ash contents of toes. The ash contents for both left and right toes varied significantly (P <0.05) between the treatment groups. The maximum percentage of ash was recorded at 200 U (left toe), and at 200 and 400 U/kg diet (right toe). The increased ash contents occurred due to the utilization of phytate-phosphorus, which was hydrolyzed by the dietary phytase. The ash content in the right toe at 600 U of phytase/kg diet was similar to that of the control.

It was reported by Tanveer *et al.* (1999) that the addition of phytase enzyme in the diet of birds with normal phosphorus content increased the total ash contents of toe by 12.1%. Kornegay (1994) suggested that toe ash content in broiler and turkey poults were the most sensitive criteria to assess microbial phytase efficacy. Supplementation of phytase enzyme at 350, 700 and 1050

U/kg soybean or corn meal had improved the toe ash percentage from 4 to 18% (Yi *et al*., 1996).

The addition of phytase also increased (P< 0.05) the calcium content in the left toe. This improvement was noted to be the highest in T_2 (200 U phytase/kg diet), followed by T_3 (36.08%), T_4 (35.82%). Lowest value was recorded in T_1 (32.22%). Statistically, there was no difference between T_1, T_3 and T_4. The contents of Ca in the right toes were lower than the left ones except for T_3, where the Ca content in the right toe was higher (47.14%). No statistical difference was observed among T_2, T_3 and T_4 in case of Ca contents of the right toe.

Table 3. Effect of varying levels of supplemental phytase enzyme on the mineral content broilers toes

Phytase level (U/kg diet)	Ash (%)		Ca (%)		P (%)	
	Left	Right	Left	Right	Left	Right
0	10.16^c	10.66^b	32.22^b	23.37^b	27.63^c	20.73^b
200	13.11^a	13.14^a	45.03^a	42.05^a	39.33^{ab}	29.73^{ab}
400	12.11^{ab}	13.65^a	36.08^b	47.14^a	47.49^a	35.44^a
600	11.21^{bc}	10.88^b	35.82^b	35.41^{ab}	32.93^{bc}	32.93^a
Mean	11.65	12.09	37.29	36.40	36.85	29.71
SEM±	0.43	0.54	1.97	3.19	2.87	2.72
LSD	1.51*	9.55*	6.80*	16.75**	9.95*	9.42*

Values with different superscript within a column differ significantly at 1 %(**), 5 %(*)

Tibia bone mineral contents

Supplemental phytase had a remarkable effect on the ash content (table 4). Significantly (P<0.01) low value (39.6%) was noted for the control, but the treatment groups had higher values viz. 56.7% in T_3, 54.47% in T_2 and 46.73% in T_4. The value of T_3 was significantly (P<0.05) higher than the control. The same trend was noted for Ca and P. The values of Ca were significantly (P<0.05) higher compared to the control group. Similarly, phytase levels had significantly (P<0.05) higher values of P compared to the control.

The ash content improved in T_2 and T_3 due to increase in level of phytase supplementation, but a significantly lower value of ash was noted in T_4, which had the highest level of phytase. Calcium content was higher in T_2 and T_3 but significantly (P<0.05) lower in T_4. The P percent in the right tibia showed the lowest value in control group (34.72%), an increase in T_2 (47.76%), and a decrease in T_4 and T_3. The difference between T_1 and T_3 were not significant (P>0.05), however, the value of T_2 was significantly (P<0.05) higher than all other treatments.

Phytase treatment of diets is reported to increase the tibia ash contents (Sebastian *et al*., 1996). Phytase addition in the diets of birds improves the ash content of the tibia by 62% (Tanveer *et al*., 1999), and ash percentage of the tibia bone is considered to be a good indicator of bone mineralization, and increased phosphorus and calcium availability, which leads to increase the calcium and phosphorus contents of the bone (Simons *et al*., 1990). Broz *et al*. (1994) found that phytase supplementation in maize and soybean meal based diets increased the tibia ash percentage in broiler chickens. Kornegay *et al*. (1996) found that tibia might be less sensitive to dietary phosphorus availability than toe ash. Qian *et al*. (1996) reported that both phosphorus and calcium account for more than 50% of the bone ash contents.

This study showed an increase in toe and tibia ash contents in chickens fed on diets supplemented with phytase. Higher contents of calcium and phosphorus in the bones of phytase supplemented chicken were due to increase in the phytate phosphorus utilization.

Table 4. Effect of varying levels of supplemental phytase enzyme on the mineral content of the tibia bones of broilers

Phytase level (U/kg diet)	Ash (%)		Ca (%)		P (%)	
	Left	Right	Left	Right	Left	Right
0	39.96[b]	40.52[b]	32.90[b]	46.88[b]	32.94[b]	34.72[a]
200	54.47[a]	53.93[a]	50.54[a]	61.77[a]	49.30[a]	47.76[b]
400	56.70[a]	50.80[a]	55.37[a]	62.69[a]	48.72[a]	37.76[a]
600	46.73[ab]	38.99[b]	55.70[a]	48.69[b]	36.94[a]	39.77[ab]
Mean	49.47	46.06	48.63	55.01	41.98	40.01
SEM±	2.08	2.55	3.49	2.76	3.40	2.32
LSD	10.93**	8.81*	12.06*	9.55*	11.76*	8.04*

Values with different superscript within a column differ significantly at 1 %(**), 5 %(*)

Economic analysis

Economic analysis showed significant ($P< 0.01$) variation between the treatment groups. The highest economic benefit (Rs. 53.93) was noted for T_3, followed by T_2 (Rs .51.06), and T_4 (Rs. 47.98). The lowest benefit (Rs. 49.57) was recorded for the control group. Based on a value of Rs. 50/kg live weight for a broiler, and a feed cost of Rs. 8/kg, the cost of feed intake was Rs. 21.27, 18.72, 16.17 and 16.61 for T_1, T_2, T_3 and T_4, respectively. These values were statistically different ($P<0.01$). The cost of phytase (based on Rs. 480/kg) in the different treatments was Rs. 0.00 for T_1, 0.09 for T_2, 0.15 for T_3 and 0.24 for T_4.

On the basis of the above calculations, net profit of Rs.8.23, 13.59 and 7.11 per bird, were recorded for T_2, T_3 and T_4 respectively. Hence, the highest profit was from the group on T_3. Gulam (2002) reported the influence of feeding enzyme supplemented rations on the profit per broiler was to be Rs. 2.80 compared to the control group in a 12-day trial.

Table 5 Effect of varying levels of supplemental phytase enzyme on overall costs and benefits of broiler production

Phytase level (U/kg diet)	Cost of chick (Rs 50/kg live wt.)	Cost of feed intake (Rs 8/kg feed)	Cost of phytase (Rs 480/kg phytase)	Gross cost (Rs.)	Gross profit (Rs.)	Net profit (Rs/broiler)
0	45.29^{d}	21.27^{a}	0.000^{d}	21.27^{a}	24.02^{d}	0.00^{d}
200	51.06^{b}	18.72^{b}	0.090^{c}	18.81^{b}	32.25^{b}	8.23^{b}
400	53.93^{a}	16.17^{d}	0.150^{b}	16.32^{d}	37.61^{a}	13.59^{a}
600	47.98^{c}	16.61^{c}	0.240^{a}	16.85^{c}	31.13^{c}	7.11^{c}
Mean	49.57	18.20	0.12	18.32	31.26	7.24
SE±	0.15	0.02	0.002	0.019	0.15	0.15
LSD	0.76**	0.09**	0.095**	0.095**	0.83**	0.83**

Values with different superscript within a column differ significantly at 1 %(**),

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