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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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The Effect of Different Levels of Dietary Phosphorus (Inorganic Phosphorus) on Performance in Broiler Chicks

A. Nouri Moghadam
Department of Animal Sciences, Azad University of Khorasgan, Isfahan, Iran

Abstract: This experiment was conducted to study the effects of available phosphorus on the growth performance, phosphorus and calcium metabolism of broiler chicks. Four hundred and five 7 days old age chicks were fed with a diet containing 0.20, 0.25, 0.30% available phosphorus (0.30, 0.35 and 0.40 % respectively total phosphorus) in a completely randomized design, consisting of 45 chicks per replicate during a 14 days experimental period (from 8 to 21 days of age). All feeding programs were isocaloric and isoprotein. chicks were put at random into 3 treatment groups (3 replicates and 135 chicks per treatment).The effects of different levels of available phosphorus on body weight, daily feed consumption, feed conversion efficiency, feed/gain ratio, weight percentage of body parts, percentage of bone ash, calcium and phosphorus percentages in bone ash, and plasma inorganic phosphorus and calcium were assessed and determined. The results showed that the effects of different levels of available phosphorus on body weight, daily feed consumption, bone ash percentage, plasma calcium and phosphorus percentages ($p<0.01$) and bone ash phosphorus percentage ($p<0.05$) were significant while no significant effects were observed in the case of feed conversion efficiency, feed/gain ratio, and plasma calcium. From the results obtained, it seems that increasing levels of inorganic phosphorus (non-phytate phosphorus) led to more efficiency in the broiler performance, calcium and phosphorus utilized by poultry.

Key words: Phosphorus, calcium, broilers, performance

Introduction

Minerals are inorganic materials occurring in nature in the form of salts or mixed with organic compounds. The availability of minerals to animals and their metabolic functions largely depend on the compound in which they are part of. Phosphorus is the second most abundant element in animal body, with 80% of phosphorus found in the bones and teeth, and the remainder located in the body fluids and soft tissue. High iron, aluminum, and magnesium contents when forming insoluble phosphate complexes can lead to reduced phosphorus absorption (Leeson and Summers, 2001).

The majority of phosphorus in plants is contained in chemical structures called phytic acids or their salts, which are known as phytates (Pallauf and Rimbach, 1997). Phytate phosphorus is relatively unavailable to monogastric animals. Thus, although plants contain substantial amounts of phosphorus, inorganic phosphorus are routinely added to mixed feeds. Phosphorus levels in feeds and feed components are reported as available phosphorus (AP); phytate phosphorus is considered to be largely indigestible. The National Research Council (1994) reports that corn has a total phosphorus level of 0.28%, whereas AP is only 0.08%; less than half of the phosphorus in soybean meal is considered available.

Frost and Roland (1991) maintained that reducing dietary phosphorus led to a significant reduction in birds' feed consumption such that the lower the phosphorus content, the less feed is consumed. According to them, as a result of phosphorus deficiency, weigh gain rate and bone ash reduces while feed conversion rate increases.

Calcium absorption mainly takes place in the duodenum and depends on body needs. Most calcium compounds are insoluble. The absorption of calcium in the intestines is facilitated and accelerated by agents that make calcium compounds soluble. The acidic conditions in the intestines are responsible for the solubility of calcium compounds and thus increased absorption of calcium. This is while alkaline conditions cause calcium compounds to sediment and, hence, it's reduced absorption (Leeson and Summers, 2001).

With few exceptions, poultry rations are based largely on cereal grains and oilseed meals. Unfortunately, approximately two thirds of the phosphorus in cereal grains and oilseed meals is present in the form of phosphorus bound to phytic acid (phytate phosphorus), which is not digested *by* poultry; most is excreted in the manure. As a result, approximately 250,000 tons of manure phosphorus is produced annually and contributes to water pollution (Cromwell, 1994). Poultry manure is often used as fertilizer on pastures and other croplands. In areas of intensive poultry production, however, the nutrient content of manure often exceeds the requirements for plant growth. If this excess occurs, the additional phosphorus can contribute to a significant environmental problem. A number of nutritional approaches are currently being evaluated to deal with the poor availability of phytate phosphorus and the resultant potential for phosphorus pollution. These approaches include: 1) formulating diets at the requirements of poultry to avoid excess phosphorus excretion; 2) adding microbial phytase to poultry diets to increase phytate phosphorus availability; and 3) genetically lowering the phytic acid content of cereal grains and oilseeds, thereby improving plant phosphorus availability.

Regarding the fact that phosphorus absorption depends on the dietary calcium/phosphorus ratio, it is clear that these two elements must be studied together. The objective of the present study is to find a level of phytate phosphorus to create the desirable conditions for calcium and phosphorus absorption through the use of an inorganic phosphorus source in an attempt to provide an economically balanced and suitable bird diet.

Materials and Methods

In this experiment, 405 one-day commercial broiler chicks of Arian strain were used. They were grouped in such a way to obtain almost equal average weights across all groups. The chicks were kept in battery cages where the bed floor was covered with wood chips. In each cage were placed common drinking water cups and feed bins. Water and feed were freely available to chicks without any control throughout the study period.

In a completely randomized design, each of the 3 experimental diets was randomly fed to three groups of chicks (with three replications for each diet). The experiment was continued from day 7 to 21. The diets included three levels of phosphorus (0.20, 0.25, and 0.30% of available phosphorus). All diets were prepared in such a manner that they contained equal levels of energy and protein. The composition of experimental diets is presented in Table 1. At 21 days of age, one hen and one rooster from each treatment were selected and strangled by breaking their necks after taking blood samples. Blood samples were transferred to lab to determine plasma phosphorus and calcium contents. Calcium and phosphorus were determined using Darman Kave Research Lab and Zistchemi Research standard kits, respectively (Baginski *et el.*, 1973; Tietz, 1986).

Body weight and feed consumption rate were measured at 7 and 21 days of age. After slaughter, percentage of body weight and percentage of body components weight were measured and then the tibia and femur bones were removed from the body, packed in nylon bags, indexed and transferred to cool mortuary (+4°C) for storage. To determine ash calcium and phosphorus contents, the bones were then transferred to lab where they were boiled in water and dried in an oven for 24 hours following flesh and cartilage removal. The products were then placed in Soxhlet apparatus for 16 hours for fat extraction which were then transferred to dry oven and electric furnace for 8 hours for treatment to obtain the ash. The ash was then weighed in order to determine the ash percentage of the bones. It was then used to determine the calcium and phosphorus contents using the standard methods recommended by Association of Official Analytical Chemists (AOAC, 1990). All facilities needed were provided by the Azad University of Khorasgan and the experiment was conducted during summer 2005.

Statistical analyses: Data were analyzed using the General Linear Models (GLM) procedure of Statistical Analyses Systems (SAS, 1999). Differences among treatment means were assessed using the Least Significant Difference test (Carmer and Walker, 1985).

Results and Discussion

As shown in Table 2, the dietary phosphorus on body weight, feed consumption, bone ash percentage, ash calcium percentage, plasma phosphorus ($P<0.01$), and ash phosphorus percentage ($P<0.05$) had significant effects while it had no significant effects on feed conversion rate and plasma calcium content. Neither did the dietary phosphorus have any significant effects on body component weight ratios nor on gain/feed consumption ratio. The significant effect of dietary phosphorus on body weight seems to be more related to increased feed consumption proportionate to higher phosphorus content. Although dietary phosphorus had no significant effect on feed conversion rate, increased phosphorus levels improved the observed feed conversion rate.

In the experiments performed by Perney *et al.* (1993), dietary phosphorus levels had significant effects on feed conversion rate.

However, no such results were observed in our study. The inconsistency between the results obtained in this experiment with finding of Perney *et al.* (1993) regarding feed conversion rate can be attributed to high dietary calcium concentrations as high concentrations reduce phytic phosphorus consumption in animal diets due to the formation of insoluble calcium-phytate.

On the other hand, this may be due to the use of over 50% of inorganic (available) phosphorus in the present study which prevented different levels of phosphorus to show their significant effects.

Although Balander and Flegal (1996) reported that different levels of dietary phosphorus on turkeys had no significant effects on body weight gain and feed conversion rate. Furthermore Sohail and Roland (1999) found that reduced levels of non phytate phosphorus and dietary calcium or both of them clearly decreased the average daily weight gain, feed consumption and feed conversion efficiency.

As seen in Table 2, the highest and the lowest

Table 1: Composition of experimental diets (7-21 days) according to kg percentage

Ingredients	1	2	3
Corn	60.45	60.11	59.88
Soybean meal	32.3	32.37	32.41
Oyster shell	2.09	1.91	1.72
Dicalcium Phosphate	0.51	0.81	1.1
Soybean oil	1.21	1.36	1.45
Mineral supplement[1]	0.3	0.3	0.3
Vitamin supplement[2]	0.3	0.3	0.3
Fish meal	2.5	2.5	2.5
Salt	0.2	0.2	0.2
Methionine	0.14	0.14	0.14
Total %	100	100	100
Calculated analysis			
Available dietary phosphorus level(%)	0.2	0.25	0.35
Total dietary phosphorus level(%)	0.3	0.35	0.4
Metabolizable energy(kcal/kg)	2900.06	2900.73	2900.22
Crude protein (%)	20.85	20.85	20.85
Energy/Protein ratio	139.09	139.1	139.09

[1]Mineral supplement provided per kilogram of diet: manganese, 80 mg; copper, 10 mg; iodine, 0.8 mg; cobalt, 0.25 mg; selenium, 0.3 mg; zinc, 80 mg; iron, 80 mg. [2]Vitamin supplement provided per kilogram of diet: vitamin A, 10000 IU; vitamin D_3, 2500 IU; vitamin E, 10 IU; vitamin B_1, 2.2mg; niacin, 30 mg; vitamin B_{12}, 0.015 mg; folic acid, 0.5mg; biotin. 0.15 mg; cholin chloride, 200 mg.

Table 2: Comparison of average values of body weight, feed consumption, feed conversion rate, weight gain to feed utilization ratio, weight ratio of body components, bone ash percentage, bone ash calcium and phosphorus percentages, and plasma phosphorus for dietary phosphorus

	Dietary phosphorus				Sources of variation
Major effects	0.3	0.35	0.4	SE	Dietary phosphorus
21-day old body weight (g)	372.6^b	380.2^a	385.6^a	10.7	**
breast weight(%)	14.9	15.1	14.9	0.7	NS
Femur weight (%)	20.2	19.8	20.1	1.5	NS
gizzard weight (%)	2.98	3.00	3.01	0.08	NS
liver weight (%)	2.48	2.50	2.49	0.02	NS
Feed consumption 8-21 days[1]	50.2^c	51.0^b	51.9^a	1.0	**
Feed conversion rate	1.62	1.60	1.60	0.03	NS
Weight gain/feed utilization	0.82	0.82	0.82	0.01	NS
bone ash (%)	49.5^b	51.5^a	51.5^a	1.3	**
ash calcium (%)	43.7^c	46.1^b	46.9^a	2.6	**
ash phosphorus (%)	17.5^b	18.8^a	18.8^a	1.2	*
plasma calcium (%)[2]	9.9	10.0	10.2	0.8	NS
plasma phosphorus (%)[3]	6.5^c	7.1^b	8.1^a	1.0	**

[1]Grams/chicken/day. [2]Mg/deciliter. [3]Mg percent. a-c: Average values with different superscripts in each column indicate significant differences among them at 0.05 percent. NS, *, and ** indicate no significant and significant at 5 and 1% levels, respectively.

responses of body weight to dietary phosphorus were observed for dietary phosphorus levels of 0.4% and 0.3%, respectively. The highest response for daily feed consumption belonged to a 0.4% level of dietary phosphorus while the lowest belonged to a 0.3% level. The responses of body weight for both levels of 0.35% and 0.4% dietary phosphorus were the same (380.2 and 385.6 grams, respectively). However, a 0.3% total phosphorus level was different from all other levels (372.6 gr). This was due to increased feed consumption with increasing dietary phosphorus levels.

In their study of the effects of three dietary calcium/ total phosphorus ratios, Liu *et al.* (1998) reported that reduced calcium / total phosphorus ratio linearly increased the average daily weight gain during the study period ($P<0.03$) and that generally, weight gain/feed consumption ($P<0.001$) and phosphorus absorption increased toward the end of their experiment period. These findings are in good agreement with our findings to the effect that body weight gain and feed consumption were influenced by different levels of dietary phosphorus but the gain/consumption ratio was not significantly affected by dietary phosphorus. The reason for the results are attributed to high dietary calcium concentrations as high concentrations reduce phytic phosphorus consumption in animal diets due to the formation of insoluble calcium-phytate.

The best responses for bone ash percentage and bone ash phosphorus percentage were obtained for a phosphorus level of 0.4% which had no significant differences with the 0.35% level. The best responses to the dietary phosphorus levels for ash calcium and plasma phosphors percentages belonged to the 0.4% level of total dietary phosphorus.

The results from Liu *et al.* (1998) showed that low calcium/phosphorus ratios linearly increased bone strength and bone ash weight. They found that diets with level calcium concentrations had a negative effect on phosphorus utilization which was due to the formation of the calcium-phytate complex. Generally, it seems that the 0.4% level of dietary phosphorus provide the best responses in the measured parameters.

The difference between results is relatively related to the conditions and quantity of phosphorus, calcium/phosphorus ratio, gut microflora, dietary composition, duration of experiment, chick strain and finding criteria used for evaluation.

For better evaluation of the effect of available phosphorus on mineral utilization it is suggested that other criteria such as plasma parameter can leads to precise results.

Conclusion and recommendations: Considering the results from the present study, it may be claimed that inorganic phosphorus influenced the improvement of dietary phosphorus utilization and suitable responses were observed at low dietary phytae phosphorus levels.

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Refrences

Association of Official Analytical Chemists, 1990. Official Methods of Analysis ,Association of Official Analytical Chemists ,. Washington DC. P: 88.

Baginski, E.S., S.S. Marie, W.L. Clark and B. Zak, 1973. Direct microdetermination of serum calcium. Clin. Chim. Acta., 46: 49-54.

Balander, R.J. and C.J. Flegal, 1996. The effect of using phosphatase enzyme on the performance of growing market turkeys and excreted phosphorus. Poult. Sci., 75. Suppl 1.

Carmer, S.G. and W.M. Walker, 1985. Pairwise multiple compariSons of treatment means in agronomic research. J. Agron, Edu.,14: 19-26.

Cromwell, G.L., 1994. Diet formulation to reduce the nitrogen and phosphorus in pig manure. *In*: Nutrient Management Symposium Proceedings, Chesapeake Bay Commission, Harrisburg, PA.

Frost, T.J. and D.A. Roland, 1991.The influence of various calcium and phosphorus levels on tibia strenth and egg shell quality of pullets during peak production. Poult. Sci., 70: 963-969.

Leeson, S. and J.D. Summers, 2001. Scott`s Nutrition of the Chicken. 4th ed. Guelph, Ontario, Canada.

Liu, J., D.W. Bollinger and D.R. Ledoux and T.L. Veum, 1998. Lowering the dietary calcium to total phosphorus ratio icreases phosphorus utilization in low-phosphorus corn-soybean meal diet supplemented with microbial phytase for growing-finishing pigs. J. Anim. Sci., 76: 808-813.

National Research Council, 1994. Nutrient Requirements of Poultry. 9th ed. National Academy Press, Washington, DC.

Pallauf, J. and G. Rimbach, 1997. Nutritional significance of phytic acid and phytase. Arch. Anim. Nutr., 50: 301-319.

Perney, K.M., A.H. Cantor, M.L. Straw and K.L. Herkelman, 1993. The effect of dietary phytase on growth performance and phosphorus utilization of broiler chicks. Poult. Sci., 72: 2706-2714.

SAS Institute, 1999. SAS User's Guide. Release 8.2 Ed. SAS Institute Inc. Cary. NC.

Sohail, S.S. and D.A. Roland, Sr., 1999. Influence of supplemental phytase on performance of broilers four to six weeks of age. Poult. Sci., 78: 550-555.

Tietz, N.W., 1986. (ED.), Textbook of Clinical Chemistry, W.B. Saunders Co., Philadelphia, p. 1351.