Poultry Science Journal

http://psj.gau.ac.ir

GUASNR

# The Effect of Phytase Enzyme on the Performance of Broiler Flock (A-Review)

Khan SA[1], Chaudhry HR[1], Butt YS[1], Jameel T[2] & Ahmad F[2]

[1]University College of Veterinary & Animal Sciences, The Islamia University of Bahawalpur, Pakistan.
[2]Department of Microbiology, University of Veterinary & Animal Sciences, Lahore, Pakistan.

***Poultry Science Journal* 2013, 1 (2): 117-125**

**Article history:**
Received: April 30, 2013
Accepted: Novamber 24, 2013
Available online: December 1, 2013

**Corresponding author:**
Haroonrashid Chaudhry , Ph.D
haroonrashid.chaudhry@gmail.com

**Keywords:**
Phytase
Microbial phytase
Energy
Broiler

## Abstract

From the last few years, the inclusion of microbial phytase in poultry diets has increased significantly, mainly in response to heightened concerns over phosphorus pollution of the environment and as cheaper means to make phosphorus available to birds from phytate. Phytate is the major form of phosphorus, abundantly found in cereal grains, beans and oilseed meals used in poultry diet but the monogastric animals like poultry birds are unable to utilize this source of phosphorus due to lack of endogenous phytase enzyme. To meet the phosphorus requirements of poultry birds, inorganic phosphates are added to the poultry rations, which lead to the problem of environmental pollution as a large amount of phosphorus is excreted in the manure. Microbial phytase is used as an alternative of this, which has beneficial effects on the growth performance, feed efficiency, protein/amino acid digestibility, energy utilization, mineral retention, and bone growth of broilers due to the direct hydrolytic effects on phytate.

---

Please cite this article as: Khan SA, Chaudhry HR, Butt YS, Jameel T & Ahmad F. 2013. The Effect of phytase enzyme on the performance of broiler flock (A-Review). Poult. Sci. J. 1 (2): 117-125.

## Introduction

Phytate is the major form of phosphorus found in cereal grains, beans and oilseed meals fed to poultry (Ravindran *et al.*, 1995). Approximately 61–70% of phosphorus found in the poultry diet ingredients is in the form of phytate phosphorus (Table 1). But the monogastric animals like poultry are unable to utilize this phytate phosphorus, as they lack endogenous phytase, and this results in the addition of inorganic feed phosphates to the poultry diets in order to meet the phosphorus requirements of poultry (Yu *et al.*, 2004). It is resulting in relatively large amounts of phosphorus in the manure that contribute to the environmental pollution (Guo *et al.*, 2009).

Exogenous phytase of microbial origin can be used as an alternative which helps to reduce phosphorus excretion in poultry (Yu *et al.*, 2004). The beneficial effect of exogenous phytases in poultry rations has been supposed to be due to the direct hydrolytic effects on phytate and the subsequent improvement in the availability of minerals, amino acids, and energy (Selle and Ravindran, 2007). It has also been suggested that phytase in the poultry diets improves gut health as indicated by reduced secretions from the gastrointestinal tract (GIT), which consequently improves the efficiency of utilization of energy (Oduguwa *et al.*, 2007; Pirgozliev *et al.*, 2008).

The main objective of this current review therefore is to determine the effect of dietary phytase feed additives on growth performance, feed efficiency, protein/amino acid digestibility, energy utilization, mineral retention, and bone growth of broilers.

**Table 1. Weighted range of total P and phytate-P concentrations, and proportion of phytate-P of total P, in important poultry feed ingredients**

| Feed Ingredient | Total P (g Kg$^{-1}$) | Phytate-P (g Kg$^{-1}$) | Proportion (%) |
|---|---|---|---|
| Cereals | | | |
| Barley | 2.73–3.70 | 1.86–2.20 | 59–68 |
| Maize | 2.30–2.90 | 1.70–2.20 | 66–85 |
| Sorghum | 2.60–3.09 | 1.70–2.46 | 65–83 |
| Wheat | 2.90–4.09 | 1.80–2.89 | 55–79 |
| Oilseed meals | | | |
| Canola meal | 8.79–11.50 | 4.00–7.78 | 36–76 |
| Cottonseed meal | 6.40–11.36 | 4.9–9.11 | 70–80 |
| Soya bean meal | 5.70–6.94 | 3.54–4.53 | 53–68 |
| By-products | | | |
| Rice bran | 13.40–27.19 | 7.90–24.20 | 42–90 |
| Wheat bran | 8.02–13.71 | 7.00–9.60 | 50–87 |

Derived from studies by Nelson *et al.* (1968), Kirby and Nelson (1988), Eeckhout and De Paepe (1994),Ravindran *et al.* (1994), Viveros *et al.* (2000), Selle *et al.* (2003), Godoy *et al.* (2005), Selle and Ravindran (2007).

## Effect on growth performance

Since the report of Simons *et al.* (1990), a lot of research investigations have been done to illustrate the effects of various microbial phytases on growth performance of poultry. Predictably, the addition of microbial phytase enzyme to diets which have inadequate amount of phosphorus has been consistently shown to enhance growth performance. In the study of Juanpere *et al.* (2004) phytase addition (500 FTU $Kg^{-1}$) to diets containing 2.7 g $Kg^{-1}$ total P increased weight gain (35 g/bird/day versus 34 g/bird/day) and feed efficiency (1.4 versus 1.5) of broiler chicks from 7 to 21 days of age. Subsequently, Pirgozliev *et al.* (2010) reported that phytase addition (250 FTU $Kg^{-1}$) to diets increased weight gain (32.2 g/bird/day versus 29.6 g/bird/day) and feed efficiency (1.47 versus 1.52) of broilers.

The comprehensive view of the effects of phytase enzyme on the growth performance of the broiler chicks is described in Table 2. This suggest that addition of phytase enzyme in the broiler feed greatly enhances the growth rate of growing chicks and the weight gain rate also increases by increasing the amount of phytase enzyme per kilograms of feed.

**Table 2. The effect of phytase supplementation (0–12,000 FTU $Kg^{-1}$) on growth performance of broiler chicks**

| Phytase (FTU $Kg^{-1}$) | Growth Performance | | |
|---|---|---|---|
| | Weight Gain (g/bird) | Feed Intake (g/bird) | Feed Conversion Ratio (g/g) |
| 0 | 287 | 381 | 1.32 |
| 375 | 399 | 490 | 1.23 |
| 750 | 424 | 505 | 1.19 |
| 1500 | 459 | 548 | 1.19 |
| 6000 | 494 | 580 | 1.17 |
| 12000 | 515 | 595 | 1.15 |

Adapted from Shirley and Edwards (2003) & Selle and Ravindran (2007).

### Effect on protein/amino acid digestibility

The level to which phytase produces improvements in protein/amino acid digestibility in broiler is unpredictable and this topic remains controversial. The observed variability appears to arise from a number of factors including:

(i) the choice of inert marker used in digestibility assays,
(ii) differences between ingredient types,
(iii) dietary levels of Ca and non-phytate-P and some evidence suggests that
(iv) Dietary electrolyte balance may be involved.

A number of studies have reported improvements, although to varying limits, in the coefficient of apparent ileal digestibility (CAID) of amino acids following phytase addition to broiler diets. In many studies the inert markers selected include chromic oxide (Kornegay, 1996; Sebastian *et al.*, 1997; Kornegay *et al.*, 1999;

Namkung and Leeson, 1999; Zhang *et al.*, 1999; Camden *et al.*, 2001; Dilger *et al.*, 2004; Onyango *et al.*, 2005), acid insoluble ash (Ravindran *et al.*, 2000, 2001; Selle *et al.*, 2003) and titanium oxide (Rutherfurd *et al.*, 2004; Ravindran *et al.*, 2006).

**Table 3. Comparative summary of the effects of phytase on coefficient of apparent ileal digestibility (CAID) of essential amino acids depending on inert dietary markers**

| Amino acid | Acid insoluble ash or titanium oxide | | Chromic oxide | |
|---|---|---|---|---|
| | CAID | Response (%) | CAID | Response (%) |
| Arginine | 0.846 | 3.48 | 0.904 | 1.03 |
| Histidine | 0.784 | 4.64 | 0.856 | 1.63 |
| Isoleucine | 0.786 | 4.28 | 0.836 | 2.55 |
| Leucine | 0.786 | 4.77 | 0.867 | 1.44 |
| Lysine | 0.825 | 3.96 | 0.878 | 1.08 |
| Methionine | 0.899 | 1.75 | 0.907 | 0.55 |
| Phenylalanine | 0.798 | 4.62 | 0.865 | 1.22 |
| Threonine | 0.738 | 6.55 | 0.784 | 2.29 |
| Tryptophan | 0.783 | 4.57 | 0.838 | 0.59 |
| Valine | 0.775 | 4.97 | 0.834 | 1.99 |
| Mean | 0.802 | 4.36 | 0.857 | 1.44 |

Derived from the studies Kornegay (1996), Sebastian *et al.* (1997), Kornegay *et al.* (1999), Namkung and Leeson (1999), Zhang *et al.* (1999), Camden *et al.* (2001), Dilger *et al.* (2004), Onyango *et al.* (2005), Ravindran *et al.* (2000), (2001), Selle *et al.* (2003), Rutherfurd *et al.* (2004), Ravindran *et al.* (2006).

In another study (Selle *et al.*, 2009), the effect of enzyme treatments on the apparent ileal digestibility of amino acids in wheat based feed was estimated. Dietary P level had no effect on the digestibility of amino acids. Individually, phytase increased the ileal digestibility of arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, aspartic acid, glutamic acid, glycine, proline and serine from 2.5% to 12.8%.

## Effect on Energy Utilization

The possibility that supplementary phytase has a positive impact on energy utilization in poultry has considerable practical implications. Early studies involving dephytinised feed ingredients showed that phytate negatively influences energy utilization in broilers (Rojas and Scott, 1969; Miles and Nelson, 1974).

Exogenous phytase has consistently increased AME of broiler diets based on wheat and/or sorghum in many studies. (Ravindran *et al.*, 1999, 2000, 2001; Selle *et al.*, 1999, 2001, 2003, 2005).These studies and several other researches (Driver *et al.*, 2006; Farrell *et al.*, 1993; Kocher *et al.*, 2003; Namkung and Leeson, 1999; Shirley and Edwards, 2003) are summarized in Table 4.

Overall, phytase supplementation increased AME by an average of 0.36 MJ kg$^{-1}$ DM (or 2.8%) over the non-supplemented controls. The percentage responses in AME following phytase supplementation are negatively correlated with the energy density of the control diets. While the data show that phytase positively influences energy utilization in broilers, the lack of a convincing rationale detracts from the reliability of this proposition.

In phytase experiments, wheat may be pre-pelleted separately to abolishthe intrinsic phytase activity as it might reduce responses of microbial phytase (Selle and Ravindran, 2007). This approach was practiced in one study (Selle *et al.*, 2001), in which phytase did not enhance energy utilization.

**Table 4. Effects of phytase supplementation on energy utilization (AME or AMEn) in broiler chickens**

| No. | Diet type | AME (MJ Kg$^{-1}$ DM) | | Response | | Phytase (FTU Kg$^{-1}$) |
|---|---|---|---|---|---|---|
| | | Control | Phytase | MJ Kg$^{-1}$DM | % | |
| 1. | Maize-Soy | 12.49 | 12.62 | 0.13 | 1.0 | 24,000, *Apergillus niger* |
| 2. | Sorghum | 12.80 | 13.10 | 0.30 | 2.3 | 750, *Apergillus niger* |
| 3. | Wheat | 14.88 | 14.96 | 0.08 | 0.5 | Mean of two phytase |
| 4. | Wheat (pre-pelleted) | 14.20 | 14.10 | -0.10 | -0.7 | 600, *Apergillus niger* |
| 5. | Wheat-Sorghum 2.3 g Kg$^{-1}$ | 13.33 | 13.52 | 0.19 | 1.4 | 400 + 800, *Apergillus niger* |
| 6. | Wheat-Sorghum 4.5 g Kg$^{-1}$ | 12.67 | 13.38 | 0.71 | 4.6 | 400 + 800, *Apergillus niger* |
| 7. | Wheat-Sorghum blend | 14.22 | 14.55 | 0.33 | 2.3 | 500, *Apergillus niger* |
| 8. | Barley per se | 12.36 | 12.69 | 0.33 | 2.7 | 700, *Apergillus niger* |

Derived from the studies Driver *et al.* (2006), Farrell *et al.* (1993), Kocher *et al.* (2003), Selle *et al.* (2001), Ravindran *et al.* (1999; 2000; 2001).

## Effect on Mineral Retention

The microbial phytase supplementation of broiler diets has very significant beneficial effects on the mineral retention. Studies show that increasing the level of supplemental phytase would increase the retention of Ca (up to 9%), P (up to 10%) and Zn (up to 16%) (Brenes *et al.*, 2003). This effect is summarized in Table 5.

## Effect on Bone Growth

Phytase supplementation to low-AP diets significantly affected tibia weight, tibia ash and calcium content in tibia ash of broiler chicks. Brenes *et al.*, (2003) reported that phytase supplementation increased tibia ash (up to 4%), and Ca (up to 2%), P (up to 1%) and Zn (up to 4%) contents in tibia ash, while Mg concentration was not affected by phytase supplementation. The effects of phytase supplementation on tibia characteristics of chicks are summarized in Table 6.

**Table 5. Effects of dietary levels of microbial phytase on calcium, phosphorus, magnesium, and zinc retention in broiler chicks from 0 to 3 weeks of age**

| Mineral | PHY(U/Kg) | Plasma Level (mg/dL) |
|---|---|---|
| Calcium | 0 | 0.64 |
| | 200 | 0.66 |
| | 400 | 0.67 |
| | 600 | 0.70 |
| Phosphorus | 0 | 0.61 |
| | 200 | 0.63 |
| | 400 | 0.65 |
| | 600 | 0.66 |
| Magnesium | 0 | 0.37 |
| | 200 | 0.37 |
| | 400 | 0.39 |
| | 600 | 0.39 |
| Zinc | 0 | 0.24 |
| | 200 | 0.25 |
| | 400 | 0.28 |
| | 600 | 0.28 |

Adopted from Brenes, *et al.*, 2003.

**Table 6. Effects of phytase on bone characteristics of broiler chicks at day 21 and day 42**

| Phytase (U/Kg) | Day 21 | | | | Day 42 | | | |
|---|---|---|---|---|---|---|---|---|
| | Tibia weight (mg) | Tibia ash (g/Kg) | Bone mineral | | Tibia weight (mg) | Tibia ash (g/Kg) | Bone mineral | |
| | | | Ca (g/Kg) | P (g/Kg) | | | Ca (g/Kg) | P (g/Kg) |
| 0 | 1021 | 300 | 320 | 180 | 3362 | 360 | 330 | 160 |
| 500 | 1351 | 360 | 330 | 170 | 5503 | 400 | 330 | 160 |
| 1000 | 1339 | 380 | 330 | 170 | 6013 | 430 | 340 | 160 |

Adapted from Guo *et al.* (2009).

## Conclusion

The current review suggested that phytase supplementation had some positive effects on the growth performance, feed efficiency, protein/amino acid digestibility, energy utilization, mineral retention, and bone growth of broilers during the whole growth period.

## References

Brenes A, Viveros A, Arija I, Centeno C, Pizarro M & Bravo C. 2003. The effect of citric acid and microbial phytase on mineral utilization in broiler chicks. Animal Feed Science and Technology, 110: 201-219.

Camden BJ, Morel PCH, Thomas DV, Ravindran V & Bedford MR. 2001. Effectiveness of exogenous microbial phytase in improving the bioavailabilities of phosphorus and other nutrients in maize-soya-bean meal diets for broilers. Animal Science, 73: 289-297.

Dilger RN, Onyango EM, Sands JS & Adeola O. 2004. Evaluation of microbial phytase in broiler diets. Poultry Science, 83: 962-970.

Driver JP, Antencio A, Edwards HM & Pesti GM. 2006. Improvements in nitrogen-corrected apparent metabolisable energy of peanut meal in response to phytase supplementation. Poultry Science, 85: 96-99.

Eeckhout W & De Paepe M. 1994. Total phosphorus, phytate-phosphorus and phytase activity in plant feedstuffs. Animal Feed Science and Technology, 47: 19-29.

Farrell DJ, Martin E, Du Preez JJ, Bongarts M, Betts M, Sudaman A & Thomson E. 1993. The beneficial effects of a microbial phytase in diets of broiler chickens and ducklings. Journal of Animal Physiology and Animal Nutrition, 69: 278-283.

Godoy S, Chicco C, Meschy F & Requena F. 2005. Phytic phosphorus and phytase activity of animal feed ingredients. Interciencia, 30: 24-28.

Guo Y, Shi Y, Li F, Chen J, Zhen C & Hao Z. 2009. Effects of sodium gluconate and phytase on performance and bone characteristics in broiler chickens. Animal Feed Science and Technology, 150: 270-282.

Juanpere J, Perez-Vendrell AM & Brufau J. 2004. Effect of microbial phytase on broilers fed barley-based diets in the presence or not of endogenous phytase. Animal Feed Science and Technology, 115: 265-279.

Kirby LK & Nelson TS. 1988. Total and phytate phosphorus content of some feed ingredients derived from grains. Nutrition Reports International, 37: 277-280.

Kocher A, Choct M, Ross G & Chung TK. 2003. Effects of phytase on apparent metabolisable energy in broiler diets based on wheat or sorghum. Proceeding Australian Symposium Poultry Science, Australia, Page, 112.

Kornegay ET. 1996. Effect of Natuphos® phytase on protein and amino acid digestibility and nitrogen retention in poultry. In: Phytase in Animal Nutrition and Waste Management. BASF Corporation, Mount Olive, NJ. Pages, 493-514.

Kornegay ET, Zhang Z & Denbow DM. 1999. Influence of microbial phytase supplementation of a low pro-tein/amino acid diet on performance, ileal digestibility of protein and amino acids, and carcass measurements of finishing broilers. In: Coelho MB & Kornegay ET. (Eds). Phytase in Animal Nutrition and Waste Management. 2nd Revised Ed. BASF Corporation, Mount Olive, NJ. Pages, 557-572.

Miles RD & Nelson TS. 1974. The effect of enzymatic hydrolysis of phytate on the available energy content of feed ingredients for chickens and rats. Poultry Science, 53: 1714-1717.

Namkung H & Leeson S. 1999. Effect of phytase enzyme on dietary nitrogen-corrected apparent metabolisable energy and the ileal digestibility of nitrogen and amino acids. Poultry Science, 78: 1317-1319.

Nelson TS, Ferrara LW & Storer NL. 1968. Phytate phosphorus content of feed ingredients derived from plants. Poultry Science, 47: 11372-11374.

Oduguwa O, Pirgozliev V & Acamovic T. 2007. Energy metabolizability and digestibility of amino acids by broilers fed malted sorghum sprouts supplemented with polyethylene glycol, charcoal, phytase and xylanase. British Poultry Science, 48: 55-63.

Onyango EM, Bedford MR & Adeola O. 2005. Efficacy of an evolved Escherichia coliphytase in diets for broiler chicks. Poultry Science, 84: 248-255.

Pirgozliev V, Oduguwa O, Acamovic T & Bedford MR. 2008. Effects of dietary phytase on performance and nutrient metabolism in chickens. British Poultry Science, 49: 144-154.

Pirgozliev V, Karadas F, Pappas A, Acamovic T & Bedford MR. 2010. The effect on performance, energy metabolism and hepatic carotenoid content when phytase supplemented diets were fed to broiler chickens. Veterinary Science, 89: 203-205.

Ravindran V, Ravindran G & Sivalogan S. 1994. Total and phytate phosphorus contents of various foods and feedstuffs of plant origin. Food Chemistry, 50: 133-136.

Ravindran V, Bryden LW & Kornegay ET. 1995. Phytates: occurrence, bioavailability and implications in poultry nutrition. Poultry and Avian Biology Reviews, 6: 125-143.

Ravindran V, Selle PH & Bryden WL. 1999. Effects of phytase supplementation, individually and in combi-nation, on the nutritive value of wheat and barley. Poultry Science, 78: 1588-1595.

Ravindran V, Cabahug S, Ravindran G, Selle PH & Bryden WL. 2000. Response of broiler chickens to microbial phytase supplementation as influenced by dietary phytic acid and non-phytate phosphorus levels. II. Effects on apparent metabolisable energy, nutrient digestibility and nutrient retention. British Poultry Science, 41: 193-200.

Ravindran V, Selle PH, Ravindran G, Morel PCH, Kies AK & Bryden WL. 2001. Microbial phytase improves performance, apparent metabolisable energy and ileal amino acid digestibility of broilers fed a lysine-deficient diet. Poultry Science, 80: 338-344.

Ravindran V, Morel PCH, Partridge GG, Hruby M & Sands JS. 2006. Influence of an E. coli derived phytase on nutrient utilization in broiler starter fed diets containing varying concentrations of phytic acid. Poultry Science, 85: 82-89.

Rojas SW & Scott ML. 1969. Factors affecting the nutritive value of cottonseed meal as a protein source in chick diets. Poultry Science, 48: 819-835.

Rutherfurd SM, Chung TK & Moughan PJ. 2002. The effect of microbial phytase on ileal phosphorus and amino acid digestibility in broiler chickens. British Poultry Science, 44: 598-606.

Sebastian S, Touchburn SP, Chavez ER & Lague PC. 1997. Apparent digestibility of protein and amino acids in broiler chickens fed a corn–soybean diet supplemented with microbial phytase. Poultry Science, 76: 1760-1769.

Selle PH, Ravindran V, Pittolo PH & Bryden WL. 1999. An evaluation of microbial phytase in sorghum-based broiler diets. Proceeding Australian Symposium Poultry Science, Australia, Pages, 97-100.

Selle PH, Pittolo PH & Bryden WL. 2001. Individual and combined supplementation of wheat-based broiler diets with phytase and xylanase. Proceeding Australian Symposium Poultry Science, Australia, Page, 246

Selle PH, Ravindran V, Ravindran G, Pittolo PH & Bryden WL. 2003. Influence of phytase and xylanase sup-plementation on growth performance and nutrient utilisation of broilers offered wheat-based diets. Asian-Australasian Journal of Animal Sciences, 16: 394-402.

Selle PH, Walker AR & Bryden WL, 2003. Total and phytate-phosphorus contents and phytase activity of Australian sourced feed ingredients for pigs and poultry. Australian Journal of Experimental Agriculture, 45: 475-479.

Selle PH, Ravindran V, Ravindran G & Bryden WL. 2005. Amino acid digestibility and growth performance interactions to phytase and lysine supplementation of lysine-deficient broiler diets. Proceeding Australian Symposium Poultry Science, Australia, Pages, 234-237.

Selle PH & Ravindran V. 2007. Microbial phytase in poultry nutrition. Animal Feed Science and Technology, 135: 1-41.

Shirley RB & Edwards HM. 2003. Graded levels of phytase past industry standards improve broiler performance. Poultry Science, 82: 671-680.

Simons PCM, Versteegh HAJ, Jongbloed AW, Kemme PA, Slump P, Bos KD, Wolters MGE, Beudeker RF & Verschoor GJ, 1990. Improvement of phosphorus availability by microbial phytase in broilers and pigs. British Journal of Nutrition, 64: 525-540.

Viveros A, Centeno C, Brenes A, Canales R & Lozano A. 2000. Phytase and acid phosphatase activities in plant feedstuffs. the Journal of Agricultural and Food Chemistry, 48: 4009-4013.

Yu B, Jan YC, Chung TK, Lee TT & Chiou PWS. 2004. Exogenous phytase activity in the gastrointestinal tract of broiler chickens. Animal Feed Science and Technology, 117: 295-303.

Zhang X, Roland DA, McDaniel GR & Rao SK. 1999. Effect of Natuphos® phytase supplementation to feed on performance and ileal digestibility of protein and amino acids in broilers. Poultry Science, 78: 1567-1572.