

Phytin Phosphorus For Eco-friendly Products

Phytase supplementation reduces supplementation of inorganic phosphorus in broiler and layer diets, improves utilisation of proteins, fats and carbohydrates and increases the availability of calcium and trace minerals. Supplemental phytase is more effective in diets containing low levels of calcium. — By Dr. S.V. Rama Rao & Dr. V. Ramasubba Reddy

Intensive livestock and poultry production is a major source of atmospheric pollutants, such as ammonia, nitrous oxide and methane carbon dioxide which may contribute to soil acidification and global warming. The majority of the pollutants are primarily being liberated into the atmosphere due to reduced digestion, absorption and utilisation of dietary nutrients. The potential impact of poor utilisation of nutrients from animal excreta on the environment is perceived as one of the major issues facing livestock producers. Therefore, a number of environmental concerns have been raised about the impact of intensified poultry production on air, ground and surface water quality.

Phosphorus is the third most expensive nutrient in poultry production after energy and protein. Animal protein supplements are generally high in phosphorus, while vegetable protein supplements are low. Vegetable protein supplements are being used nowadays in increased quantity due to high cost, non-availability and possible presence of pathogenic micro-organisms like E.coli and Salmonella in animal protein supplements. The major portion of the phosphorus in plant feed ingredients is in the form of phytic acid. Phytic acid is myoinositol, esterified on each alcoholic group with orthophosphoric acid. Phytic acid contains about 28% phosphorus in the form of phosphoric acid. Calcium and magnesium salts of phytic acid is the phytin and is the primary storage form of phosphorus (60-90%) in plant seeds. High concentration of the phytate is found in the aleurone layer of seeds in case of wheat, barley, and oats and in the embryo in maize and

beans. Excessive phosphorus fertilisation of soil could result in higher phytate levels in plant materials.

Deleterious effects of phytin

The nutritional significance of phytate is complicated by protein – mineral – carbohydrate – fatty acid – phytate interaction. The phosphoric acid in the phytin molecule being a strong acid has affinity to di- and tri- valent cations like calcium, magnesium, zinc, copper, cobalt, manganese, iron and molybdenum, reducing their solubility and increasing the excretion of phosphorus, calcium, and trace elements in faeces causing environmental pollution.

Phytin also forms an insoluble complex with protein reducing the protein solubility by forming an ionic bond between the

phosphate group of phosphoric acid and amino groups like lysyl, histidyl and arginine under acidic condition and carboxyl group of some amino acids under neutral conditions. In soybean meal usually about 2-3% of protein is bound with phytin. Further, the bound form of protein is less susceptible to proteolytic digestion.

The adverse effects of phytate on the availability of various nutrients could be due to inhibitory effects of phytin on the activity of several digestive enzymes including trypsin, pepsin, and alpha amylase. Calcium phytate complexes with starch and fatty acids and forms insoluble soaps in the gastrointestinal tract of chicken, reducing the digestibility of carbohydrates and fats.

Availability of Phytin Phosphorus

The deleterious effects of phytin can be minimised if the bioavailability of phosphorus from phytin can be enhanced. Birds lack endogenous phytase. Several factors influence the bioavailability of phytin phosphorus. These are detailed below. Improving the phytin phosphorus availability would enable a reduction in the dietary phosphorus content and also reduces excretion of phosphorus, nitrogen, and trace minerals into the environment.

Age of bird: Phytin phosphorus utilisation increases from 20 to 49% as the age of the chick increased from 4 to 6 weeks. Mature hens utilise phytin phosphorus better than chicks. WL layer utilises phytin phosphorus even up to 50%.

Composition of dietary fat: Saturated fatty acids in the diet decrease the phytin phosphorus utilisation.

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Inorganic phosphorus in diet: Phytin hydrolysis is reduced by the addition of inorganic phosphorus. Birds are able to utilise substantial amounts of phytin phosphorus in diets having inadequate quantities of inorganic phosphorus. The effectiveness of phytase in broiler diets also reduced as the level of total or non-phytin phosphorus is increased.

Calcium and calcium:phosphorus ratio in diet: The phytin hydrolysis is inversely related to dietary calcium levels. A high molar ratio of calcium to phytate in a diet leads to formation of insoluble penta calcium – phytate complex in intestine, which is resistant to phytase action.

Wider calcium, phosphorus ratio also inhibits phytase activity and reduces the phytin availability. The extra calcium competes with phytate for the active sites on the enzyme. Excess dietary calcium and phosphorus forms flocculent precipitate of calcium phosphate in the duodenum and the precipitate are excreted along with other trace elements.

Phytase supplementation is not found effective in improving the utilisation of phytin phosphorus in the presence of normal levels of dietary calcium (1.0%) in broiler diet. At lower dietary calcium: phosphorus ratio (1.1), the phytin is available for growth and bone mineralisation. The level of calcium should be reduced to between 0.6 to 0.75%, when phytase is supplemented in boiler diet. In layers also increasing the dietary calcium from 3 to 4% reduced the phytin phosphorus utilisation.

Cholecalciferol and its metabolites in diet: Vitamin D₃ increases the phytin phosphorus retention in bone by improving the absorption of calcium, hydrolysis and subsequent absorption of phytin phosphorus. Vitamin D₃ or its metabolites (i.e. 1,25 (OH)₂ D₃) enhanced the phytin phosphorus utilisation up to 60% in broilers. Metabolites of cholecalciferol stimulate the more efficient use of calcium and the lower dietary calcium levels sought would enhance phytase activity. It has been demonstrated that supplemental dietary cholecalciferol increases the activity of phytase and leads to improvement in phytin phosphorus utilisation. Supplementation of metabolites of cholecalciferol and phytase showed synergistic effect on phytin utilisation in poultry. Combination of 1,25 (OH)₂ D₃ and phytase is more effective than either one individually in improving the performance of birds fed on a low P diet.

Dietary fibre content: The cation exchange properties of added fibre may reduce the effective concentration of cation in the gastrointestinal tract and increase phytate hydrolysis. The water holding

capacity or the ability of fibre to produce enlargement of the gastrointestinal tract may also affect the phytate hydrolysis. The fibre from the sunflower meal, however did not influence the phosphorus availability.

Heat treatment of feed ingredients: Cooking or autoclaving reduces the phytic acid content by about 67 to 87%, respectively. Autoclaving the de-oiled rice bran enhanced the hydrolysis of phytin phosphorus, thereby improved the phosphorus availability. It is presumed that pelleting may improve the phytin phosphorus availability. But, several reports have failed to show beneficial effect of pelleting on phytin phosphorus content of feed.

Acid treatment of feed ingredients: Phytase activity is accelerated by acid supplementation to the diet. Washing the feed ingredients with 1 N HCl removes the phytin by about 87% in soybean. Acidification of broiler diets with propionic, citric or phosphoric acids improves bone calcification. In the acidic medium of the gastro-intestinal tract, calcium absorption may improve.

Leaf meal and other feed ingredients: Leaf meals of the Solanaceae family like *Cestrum diurnum* contain considerable amount of 1,25 (OH)₂ D₃ the active metabolite of vitamin D₃. The *Cestrum diurnum* plant grows ubiquitously along the fences, sides of road and in neglected fields and pasture lands.

Dietary levels of ascorbic acid: Supplementation of ascorbic acid (50 mg/kg) in broiler diets improves the tibia ash, tibia breaking strength and calcium content in tibia ash.

Dietary levels of magnesium and zinc: Magnesium is known to improve the activity of endogenous phytase. Signs of phytate intoxication in mature rates can be reduced by dietary supplementation of magnesium.

Phytase as a possible solution: Phytase is present in few vegetable feed ingredients (*Table 1*). Various micro-organisms during their growth also produce phytase. Plant phytase – Some of the common feed ingredients like wheat, oats, barley, alfalfa meal contain considerable quantity of phytase (*Table 1*). Replacing soybean meal with wheat improved the hydrolysis of phytin. Phytate hydrolysis is chicks fed a diet containing wheat bran was greater than that of those fed the corn-soya diet.

Microbial Phytase - Several micro-organisms produce phytase during their growth and multiplication. Commercially, phytase is being produced from different strains of *Aspergillus ficcum* and *Aspergillus Oryza*. Phytase acts on phytin and

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liberates the bound inorganic phosphorus, inositol and minerals from phytin molecule. The activity of the enzyme is quantified as phytase units (FTU). One unit of phytase activity is defined as the amount, which liberates one μ M of inorganic phosphorus per minute from an excess of sodium phytate at 37° C and pH 5.5. Microbial phytase is twice as active as plant phytase (from wheat). Microbial phytase has two pH optima at 2.5 and 5.5, while plant phytase has only one pH optimum between 4.0 – 6.0. Therefore most of the plant phytase usually undergo irreversible inactivation at pH (2.5) prevailing in the proximal end of GI tract of the chicken.

Stability of phytase - Microbial phytase is stable up to 6 months in a cool and dry place. In compounded feed, a loss of 10-15% enzyme activity is expected when stored at room temperature for four months. To avoid any processing losses during pelleting, the pelleting temperature should not exceed 65° C while incorporating phytase in the diet. Post pelleting application of phytase in liquid form is being followed in recent times to avoid possible loss of enzyme activity during pelletisation of feed. Monohydrate forms of trace mineral salts are preferred over penta- or hepta-hydrate forms when using the phytase in poultry diets. Separate premixes may be prepared for trace minerals and enzyme while compounding the diets.

Beneficial effects of supplemental phytase - Phytase supplementation increases the phytin phosphorus utilisation in the chicks' intestine and also reduces the phosphorus losses in excreta. Hydrolysis of phytin improves the overall nutritive value of diet through better utilisation of trace minerals, protein, carbohydrates. The apparent faecal and ileal digestibility of major amino acids increased with phytase supplementation to a low calcium and phosphorus broiler diets. Microbial phytase supplementation to a low phosphorus diet increased retention of total phosphorus, calcium, copper and zinc. Therefore the availability of zinc, manganese, calcium and magnesium increased in chicks with phytase supplementation in their diets. The dietary requirements of calcium can be reduced by about 33% in diets supplemented with phytase.

Phytase supplementation in broiler diet reduces the necessity of supplementation of inorganic phosphorus and phosphorus contents in excreta (*Table 2*) without affecting the weight gain, feed efficiency and bone mineralisation. Similarly, in WL layers also supplementation of microbial phytase sustained egg production (*Table 3*) on low phosphorus diets without affecting the shell quality and feed efficiency.

Table 1: Phytase activity in common feed ingredients

Feed ingredient	Phytase activity (PU/kg)
Rye	5130
Triticale	1688
Wheat	1193
Barley	582
Peas	116
Wheat bran (fine)	4601
Wheat bran (pellets)	2573
Rice Bran	122

Eeckhout and DePaepe (1994)

Supplementation of microbial phytase is more effective in broiler diets containing lower dietary calcium levels. The enzyme improves the bird's performance primarily through improving the bioavailability of phosphorus from phytin. The associative beneficial effects of enhancing the phytin utilisation are improving the utilisation of essential trace minerals, protein, amino acids, energy, carbohydrates etc. in addition to transforming the poultry farming as more environmentally friendly, by decreasing the quantity of unutilised nutrients in the excreta. — *Dr. S.V. Rama Rao & Dr. V. Ramasubba Reddy, Dept of Livestock Production and Health, Rajendranagar, Hyderabad 500 030, India.*