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Review Article
Exogenous Enzymes and the Digestibility of Nutrients by Broilers: A Mini Review

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Abstract
The feed fed to broilers is a determinant of digestibility, absorption and utilization of nutrient by the birds. The increasing cost of poultry production currently for feed formulated from conventional feed ingredients has made the use of cheaper, lesser known and unconventional feed ingredients a possible way of reducing the cost of production and providing more profit to poultry producers. However, most of the alternative feed ingredients are richer in Non-Starch Polysaccharide (NSP) content, the high content of NSP invariably affect animals' performance in different ways. To mitigate the anti-nutritional factors of NSP, the use of feed enzymes are employed. This is so, since the endogenous enzyme secreted in the gastro-intestinal tract of broilers cannot digest NSP, therefore, it is desirable to supplement high fibrous feed with exogenous enzymes for effective and efficient digestion of NSP content and better performance of the birds in terms of feed intake, growth rate, feed conversion efficiency, body weight gain and carcass characteristics. These exogenous enzymes are readily obtainable from different microorganism such as *Bacillus subtilis*, *Trichoderma longibrachiatum, Aspergillus niger*, *Trichoderma viride*, *Humicola insolens*. The enzymes preparations are available under various trade names such as Nutrase xyla, Histazyme, Avizyme, Natugrain, Allzyme, Grindazyme, Roxazyme G, Avizyme, Maxi-grain, Natuzyme and others. In this review, exogenous enzyme for broiler's diet, features of bacterial and fungal xylanase enzymes, effect of xylanase and phytase on broiler nutrition, qualities of commercial enzymes and benefits of enzyme supplementation was discussed.

Key word: Broiler, exogenous enzyme, non-starch polysaccharide, nutrient digestibility, poultry feed

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INTRODUCTION

Digestibility of feed ingredient is an important factor in feed formulation, the degree of digestion of the nutrients in the digestive system is based on the type of feed given to animals. Feed with high digestibility leads to high nutrient retention and high performance, while feed that has low digestibility results in low nutrient retention and poor performance. Nutrient digestibility in broiler is affected when feed ingredient contains higher levels of indigestible components[1]. Maize most often constitutes the highest proportion of energy source ingredient in diet formulation of any poultry ration and this high inclusion rate translates to high cost of feed because of seasonality in maize production and competition for maize by man, animal and industry. Poultry feed is costly and subsequently result in high cost of production and reduced profitability. The use of cheaper, lesser known and unconventional feed ingredients may represent a low-cost route to reduce the cost of production. Hence, partial or full replacement of maize with farm wastes, biological products, industrial products and by-products from agricultural processing facilities is one of the identified ways of reducing total poultry production cost. However, most of the available alternative sources to maize are fibrous and are generally low in nutrients. Among other reasons for excluding the use of high fibrous feed ingredients in poultry diets is the decrease in digestibility of the nutrient[2-4], as a result of presence of NSPs component[5]. Examples of compounds classified as NSPs includes cellulose, hemicellulose, pentosans (D-glucans, mannans, arabinans and galactans, galactomannan, xyloglucans) and pectic polysaccharides (polygalacturonans, rhamnogalacturonans)[1].

Environmental growth conditions and crop variety are determinants of NSPs content. Generally, crops that are adapted to tropical climate are known to have higher lignin and cellulose contents with lower digestibility which and invariably affect animals' performance in different ways as compared to same crop variety in the temperate climate[6]. NSPs are big variety of polysaccharide molecules, composing most of the representative compounds of the cell wall. NSP can be soluble or insoluble in water[7,8]. Insoluble NSP are indigestible and in normal amounts, they maintain the normal motility of the gut[9]. Conversely, soluble NSP are more susceptible to biological hydrolysis, particularly at the end region of the digestive tract of birds, like the caecum. An anti-nutritive effect of soluble NSP exhibited in poultry is an increase in viscosity of the digesta. An increase in digesta viscosity leads to reduction in passage rate of the digesta and reduces intake of feed and consequently affect nutrient digestibility[10,11]. It also causes gut physiology modification that may lead to hypertrophy of the gastrointestinal tract. Furthermore, the lower intestinal transit time predisposes the bird to the multiplication of a fermentative anaerobic microflora in the upper regions of the gastrointestinal tract.

EXOGENOUS ENZYMES FOR BROILER'S DIET

Enzymes are chemicals or biological catalysts which speed up biochemical reactions and do not get used up in the process. Characteristically, most enzymes are proteins and so display the properties of protein. The activity of enzymes can be affected by several factors including the concentration of the specific enzyme, substrate, pH, time and temperature as well as the salts, activator or inhibitor in the reaction buffer among others. The activity of enzyme is obvious in all catabolic and anabolic aspects of metabolism beginning with digestion of the nutrient. Usually, the enzymes added to animal's feed to produce a desirable effect are referred to as exogenous while those secreted by the animal are called endogenous[12]. These exogenous enzymes are produced industrially for commercial purposes among which is the inclusion in animal feed as additive[13,14]. The commercial enzymes may be manufactured from microorganisms, plants and animals, however, enzymes from plants and animals are limited in production for several reasons. Cultivation of plants is limited to regions where planting such a plant is suitable and this is predominantly seasonal and this can impede stable production from plant source. Additionally, the total concentration of enzymes in the tissues of plant are considerably low, therefore, producing a large amount of plant material would be required to meet stable enzyme production. Conversely, the enzymes produced from animal are mostly by-products of meat industry and so it is limited in supply. Moreover, there is competition with other end users for the supply glands. In contrast, microorganisms are enriched with degree of potentials. Microorganisms can produce large collection of series of enzymes. This singular benefit has been exploited commercially over the years[15]. The microbial enzymes can be produced in amounts sufficient to meet the market demands.

Furthermore, the microbes are not affected by seasonal fluctuations and there are possibilities of manipulating their genetics and environment to improve and increase yields of the desired enzymes in a way that may not be possible with higher animals. In addition, the microbial enzymes produce a wide spectrum of properties that makes them utilizable for quite specific applications[6]. Microbial exogenous feed enzymes can be produced naturally from occurring bacteria, fungi and yeast. Common microbial strains for commercial feed enzyme production include *Bacillus subtilis*, *Trichoderma longibrachiatum*, *Aspergillus niger*, *Trichoderma viride*, *Humicola insolens*. The mutant or genetically modified strains of these microorganisms, yielding considerable amounts of a specific enzyme, are cultured on starch and sugar hydrolysis substrates using recent fermentation technology[16,17].

The particular enzyme produced is separated and extracted from the source of the microorganisms used and then stylized before being prepared as liquids or free flowing powders to be incorporated into feeds. Most commercial feed enzymes used as additives are preparations of various types of enzymes[18]. Some of the most common preparations available in the market come under various trade names such as Maxi-grain containing A-amylase, xylanase, β-glucanase, Exo-cellulase, pectinase, protease, phytase and lipase; Nutrizyme containing cellulose, amylase, hemicelluloses, B-glucosidase, pectinase and protease; Polyzyme containing xylanase, phytase, cellulase and protease; Novozyme Sp-243 contains cellulose, amylase beta glucanase and pectinase; Natuzyme containing β-galactosidases, β-glucanase, xylanase, phytase, protease, lipase, pectinase and trace amount of amyloglucosidase, hemicellulase, acid phosphatase; Selfeed contains cellulose, amylase, protease, pectinase and lipase; Other commercial enzymes includes: Nutrase xyla, Hostazym, Avizyme, Natugrain, Allzyme, Grindazyme, Roxazyme G, Avizyme. Phytases, carbohydrases and proteases are mostly considered for use in poultry and swine feeds[19]. The incorporation of these exogenous enzymes into broiler's diet could enhance the digestibility of the alternative and cheaper feed ingredients to obtain maximum and better performance

FEATURES OF BACTERIAL AND FUNGAL XYLANASE ENZYMES

Bacterial xylanase has some very distinctive and valuable characteristics such as thermal stability and this distinguishes it clearly from fungal xylanase preparation[8,9], The resistance ability of bacterial xylanase enzyme against high temperatures is strongly associated with their origin. According to Hesselman and Aman[20], the fungal enzymes has lower ability of heat resistance compared to bacteria enzymes, that is, bacterial enzyme preparations have a higher thermal stability than fungal counterpart therefore, bacterial enzyme do not require protective coating for use as feed additive. A bacterial enzyme starts losing activity when temperature exceeds 75°C. Additionally, the pH profile of bacterial xylanase differs from that of the fungal xylanase preparations. At a neutral pH of 6-7 bacterial xylanase reaches their maximal activity; hence, they perform maximally on feed most of the time in the small intestine. Nevertheless, fungal xylanases have the ability to complement bird's own digestive enzymes and they are active under the condition found in the gastrointestinal tract (GIT). The characteristics of been able to disperse evenly in animal feed underscores its acceptability as animal feed enzyme.

Xylanase is a group of glycoside hydrolase enzymes that break down the linear polysaccharide xylan into simple sugars called xylose. Xylanase enzyme degrades the hydrolysis of 1,4 β-D-xylosidic linkages in xylans to produce D-xylose[8]. An important role play by xylanases is in the degradation of agro-industrial waste to useful products that can be used in animal feed; some previous researches have shown that the supplementation of wheat-based diets with xylanases can result to reduced digesta viscosity by partially breaking down NSP of wheat leading to improvements in feed intake, feed conversion ratio, digestibility of nutrient and growth performance of poultry birds. Results of past research shows that the supplementation of wheat-based diets with xylanase degrade portion of arabinoxylan content into small fragments (mainly xylose and arabinose)[21-24].

Furthermore, separate studies showed additional effect of an improvement in chicken immunity by the supplementation of a wheat-based diet with xylanase[25], reduction in the detrimental effect of *Salmonella Typhimurium* infection or ameliorate barrier impairment of intestinal mucosal of broiler chickens by *Salmonella Typhimurium*[26]. Generally, it was observed that the primary beneficial effect of feed xylanase is in the reduction of intestinal mucosa viscosity. The partial hydrolysis of NSP in the upper digestive tract enhances xylanase ability to limit the formation of viscous digesta, resulting in a reduction of digesta viscosity in the small intestine and release of the nutrient encapsulated in cell wall polysaccharides[27]. The growth-promoting effect of xylanase related to degradation of some polysaccharides in the digesta in the small intestine was reported by Gao *et al.*[28]. However, Gao *et al.*[28] reported that available information on the effects of supplementing wheat based diets with xylanase on the degradation of NSP in different sections of the gastrointestinal tract (GIT) of broilers and the subsequent release of some simple sugars and oligosaccharides is limited.

The indigestible part of grains called phytic acid which is also referred to as phytate can be degraded by an enzyme called phytase, phytate can bind starch, protein and fat, forming nutrient complex in the anterior part of the digestion and make it less accessible from endogenous enzymes. Phytate inhibitory effect on other endogenous proteolytic enzymes (trypsin, amylase, pepsin) activities has been reported, reducing protein digestibility[29]. Phytase enzyme cannot be produced by broilers endogenously. Hence, researchers in the field of broiler nutrition came up with the idea of dietary phytase enzyme supplementation, exogenously, so as to make available encapsulated nutrients within the cell wall of some agro industrial by-products[30]. Phytase enzyme is used to improve the nutritive value of agricultural wastes by the release of the inorganic phosphate from phytate and thereby, reduce environmental pollution caused by increase phosphorus released in the droppings. Phytase increase the availability of phosphorous from the bound nutrient and then the animal will be able to utilize it, Kiarie *et al.*[31] reported enhanced chicken performance in growth and utilization of nutrients by broiler chickens given soybean meal-based diets supplemented with phytase. Phytase is the only enzyme that releases phosphorus of plant origin. It releases the bound minerals, proteins and amino acids from phytate complex.

Due to unavailability of endogenous phytase in the avian gut phytic acid is resistant generally to degradation in the gut of broilers[32]. Most grains, oilseed meals and plant derived products contain about 60-80% of phosphorus content which is a high level of phytic acid, the phosphorus present in the phytate is not release for utilization by broiler chickens due to the unavailability of innate enzymes needed to break down phytate into inositol and inorganic phosphorus. Several multivalent cations mainly zinc, manganese, calcium, ferrous and ferric iron bio-availability is reduced in the indigestible constituents by forming insoluble phytate metal complexes. Incorporation of exogenous phytase into broiler's diet can improve phosphorus digestion significantly through degradation of plant derived phytate[33]. Several investigations on the supplementation of microbial phytase showed that phytase can increase the feed intake and body weight gain in broiler chickens[32,34]. Erdaw *et al.*[35] reported that supplementation of low phosphorus maize-soybean diet with microbial phytase increased the availability of phosphorus for utilization by the birds and decreased the amount of phosphorus in the droppings. Madrid *et al.*[36] found that addition of multi enzyme including phytase to wheat-soybean meal diet increase nutrient digestibility of broiler chickens produced using different rearing conditions.

BENEFITS OF EXOGENOUS ENZYME SUPPLEMENTATION

Enzymes have been in use for centuries in cheese making and brewing. Modern enzymology started in 1870 when refined rennine from calves' stomach was used for cheese production[27]. Since then, production technology and knowledge about the mode of operation of enzymes progressed dramatically. Enzymes have been in usage for more than 30 years in the feed industry. Arising from the benefits of feed enzymes the poultry industry is becoming receptive to the use of exogenous enzymes increasingly. Supplementation of enzymes to the poultry diets has shown significant effect on the nutrient digestibility of high fibrous diets and this increased digestibility leads to better growth performance[13]. The productive value of unconventional feeds can be improved by the addition of exogenous enzymes and such allow greater flexibility in diet formulation. Enzyme supplementation of poultry diets has nutritional, economic and environmental advantages, some of which has been reported in researches[37].

The dietary enzyme supplementations are used to increase the feed ingredients energy value and enhance the digestibility, absorption and utilization of carbohydrates, proteins, fats and release phosphorus from indigestible plant materials, leading to a reduced excretory rate of phosphorus and nitrogen in undigested nutrients into the environment and, hence, reduced environmental pollution[3]. Enzyme supplementation to provide essential nutrients has been found to be the most feasible economic and preferred method of improving the utilization of alternative feed ingredients to maize. Feeding of high fibrous diets to broilers will not be adequately utilized because they cannot easily digest them. More so, a fibrous diet has anti-nutritive effect which is manifested by wet droppings and poor utilization of nutrients. Broilers innate digestive enzymes cannot properly digest fibrous diet because of high fibre content. Therefore, adding some exogenous enzymes, into the feed will enhance their performance, reduces fecal volume and wet droppings. A reduced output and production of drier organic matter to the environment is an important quality of feed enzymes because excessive output of nitrogen and phosphorous is a major problem of environmental pollution in densely populated areas. The supplemental enzymes allow the use of wide range of fibrous ingredients without compromising the bird's performance and hence provide great flexibility in compounding least cost feed with cheaper feed ingredients. Enzymes when also been supplemented in feeds has been shown to improve animal health by preventing certain disease such as coccidiosis and elimination of excessive fermentation. Dietary enzyme supplementation of broilers cereals-based diets has resulted in improved nitrogen and starch digestibility as well as improved absorption of proteins, carbohydrates and lipids[38].

Using specific enzymes in poultry nutrition makes it possible to use feed ingredients with lower nutritive value. Cereals with lower nutritive value are usually cheap, which may be an added opportunity for feed manufacturers. Dietary supplementation of cereal based diets for broiler chickens with microbial and pento-sanase and fungal β-glucanase activity improved feeding value of conventional and unconventional feed resulting in improved feed intake, feed conversion, growth rate and reduction in sticky dropping[38]. Kiarie *et al.*[39] recorded a similar increase in body weight gain, an improvement in feed gain ratio and diet energy with xylanase supplemented corn or wheat diet. Chakdar *et al.*[9] also showed that chicken performance and nutrient digestibility are influenced by the inclusion of bacterial- or fungal-originated xylanase into a corn and wheat-based diet to a considerable degree. Supplementation of wheat based diets with xylanase can eliminate the antinutritive effect of the pentosans (arabinoxylans) in chick. An improvement in metabolizable energy value utilizing efficiency in broiler diets supplemented with enzyme diet was also observed by Dourado *et al.*[40] and Zhou *et al.*[41].

CONCLUSION

It can be concluded that addition of exogenous enzymes to broiler' diets formulated from cheap alternative feed ingredients can improve feed intake, feed conversion ratio, nutrient digestibility, absorption and utilization of nutrients, stimulate immune system, reduce digesta viscosity and environmental pollution from undigested phosphorus and nitrogen. Therefore, supplementing broiler chicken diet with exogenous enzyme is highly beneficial for a least cost economic production of broiler chicken.

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