International Journal of Bioorganic Chemistry
2016; 1(1): 1-7
http://www.sciencepublishinggroup.com/j/ijbc
doi: 10.11648/j.ijbc.20160101.11

Review Paper on Enzyme Supplementation in Poultry Ration

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To cite this article:
Mulisa Faji Dida. Review Paper on Enzyme Supplementation in Poultry Ration. *International Journal of Bioorganic Chemistry.* Vol. 1, No. 1, 2016, pp. 1-7. doi: 10.11648/j.ijbc.20160101.11

Received: November 24, 2016; **Accepted**: December 22, 2016; **Published**: January 17, 2017

Abstract: This review paper is prepared with objective of to revise the available scientific information about the role and source of enzyme supplementation in poultry ration. The biggest single expense in any system of poultry production is feed accounting for up to 70% of total production cost per bird. The poultry industry readily accepts enzymes as a standard dietary component, especially in wheat and barley-based rations. Enzymes are biological catalyst composed of amino acids with vitamins and minerals. They bring about biochemical reactions without themselves undergoing any change. Poultry naturally produce enzymes to aid the digestion of feed nutrients. However, they do not have enzyme to break down fiber completely and need exogenous enzymes in feed to aid digestion. According to the purpose of application, feed enzymes can be fundamentally divided in to enzymes which are to quantitatively supplement endogenous digestive enzymes of mono gastric animals (Proteases, lipases, Amylases) and enzymes which are not produced by mono gastric animals (β-glucanases, Pentosanases and Phytases). Specific degradation site in the molecule, PH value, temperature, and presence of aerators / inhibitorsare some factors affecting the activity of enzyme. Bacteria, fungi and yeast are micro-organisms used as a source of enzyme in poultry ration. Some of the enzymes that have been used over the past several years or have potential for use in the poultry feed industry include cellulase (ß-glucanases), xylanases and associated enzymes, phytases, proteases, lipases, and galactosidases. The benefits of using enzymes in poultry diets include not only enhanced bird performance and feed conversion but also less environmental problems due to reduced output of excreta, including reducing the gut viscosity, increasing the effectiveness of host (endogenous) enzymes**,** alteration in feed passage rate, effect on excreta characteristics, effect on litter problems, release of nutrients, availability of phosphorus, increase in available energy, and improvement in nutrient digestibility. The degree of improvement obtained by adding enzymes to the diet depends on many factors including the type and amount of cereal in the diet, the level of anti-nutritive factor in the cereal which can vary within a given cereal (for example, low-versus high-ß-glucan barley), the spectrum and concentration of enzymes used, the type of animal (poultry tend to be more responsive to enzyme treatment than pigs), and the age of the animal (young animals tend to respond better to enzymes than older animals), type of gut micro flora present and the physiology of the bird.

Keywords: Poultry Ration, Enzyme, Micro-Organisms

1. Introduction

The biggest single expense in any system of poultry production is feed accounting for up to 70% of total production cost per bird. Poultry naturally produces enzymes to aid the digestion of feed nutrients. However, they do not have enzyme to break down fiber completely and need exogenous enzymes in feed to aid digestion. Plants contain some compounds that either the animal cannot digest or which hinder its digestive system, often because the animal cannot produce the necessary enzyme to degrade them. Nutritionists can help the animal by identifying these indigestible compounds and feeding suitable enzyme. These enzymes come from microorganisms that are carefully selected for the task and grown under controlled conditions [1]. The poultry industry readily accepts enzymes as a standard dietary component, especially in wheat and barley-based rations. But still many questions are partially answered. For example, how do enzymes work? Do growth rates reflect differences in the potency of different enzyme preparations? What is the link between gut viscosity, enzyme

action and growth rates? And are enzymes necessary in all poultry rations? Wheat and rye contain relatively high levels of arabinoxylans or pentosans (50-80 g/kg dry matter for wheat; 100 g/kg dry matter for rye) which can also have a negative effect on broiler performance[2]. Ingestion of Non Starch Polysaccharides by monogastrics results in increased viscosity of the digesta. This increased viscosity reduces the passage rate of the feed leading to overall reductions in consumption and decreased performance, sticky droppings and dirty eggs. The addition of enzymes to the diet to address NSP viscosity can improve feed efficiency, improve manure quality and increase the use of lower cost feed ingredients[3].

The objective of this review paper is:

- To review the role of enzyme in poultry ration
- To review the source of enzyme in poultry ration

2. Enzyme Supplementation in Poultry Ration

2.1. Enzyme

Enzymes are biological catalyst composed of amino acids with vitamins and minerals. They bring about biochemical reactions without themselves undergoing any change. The benefits of using enzymes in poultry diets include not only enhanced bird performance and feed conversion but also less environmental problems due to reduced output of excreta. In addition, enzymes are a very useful tool in the study of physiological and metabolic mechanisms[4].

2.1.1. Characteristics of Enzymes

i. Specific Degradation Site in the Molecule

The important feature of enzymes is that the rate of an enzyme catalyzed reaction increases with increasing substrate concentration because more substrate molecules can collide with active sites, so more enzyme-substrate complexes form, to the point where there is no further response and the enzyme is said to be saturated. Therefore, we need to match the amount of enzyme with the quantity of substrate [5].

ii. PH Value

Optimal pH is the characteristic pH at which the enzyme has the maximal catalytic power. pH 7.0 is suitable for most enzymes. Particular examples are pH (pepsin) = 1.8 and pH (trypsin) = 7.8. The pH affects the charge of the amino acids at the active site, so the properties of the active site change and the substrate can no longer bind. For example a carboxyl acid R groups will be uncharged a low pH (COOH), but charged at high pH (COO^-).

iii. Temperature

For warm blood species 35 ~ 40°C is ideal temperature. Reaction rates increase by 2 folds for every 10°C rise. Enzyme and substrate molecules both have more kinetic energy and so collide more often, more molecules have sufficient energy to overcome the activation energy. Higher T will denature the enzyme. But there are enzymes that work best at very different temperatures, e.g. enzymes from the arctic snow flea work at -10°C, and enzymes from thermophilic bacteria work at 90°C.

iv. Presence of aerators / inhibitors

Inhibitors are certain molecules that can decrease the catalytic rate of an enzyme-catalyzed reaction. Inhibitors can be normal body metabolites and foreign substances (drugs and toxins). The inhibition process can be either irreversible or reversible. Irreversible inhibitors are covalently bound to the essential groups of enzymes and cannot be removed with simple dialysis or super-filtration. Binding can cause a partial loss or complete loss of the enzymatic activity. Reversible inhibitors are bound to enzymes non-covalently and characterized by equilibrium between free enzymes and inhibitor-bound enzymes. Animal nutrition requires the enzymes, which are active at 40°C and also withstand at 70-80°C (Pelleting temperature).

2.1.2. Sources of Enzymes

Microorganisms that generally involved in production of enzymes are; Bacteria (Bacillus subtilis, Bacillus lentus, Bacillus amyloliquifaciens, B. licheniformis and Bacillus stearothermophils), Fungus (Triochodermalongibrachiatum, Asperigillusoryzae and Asperigillusniger) and Yeast (S. cerevisiae). Fungi produce enzymes for degradation of various substances. But they all have one thing in common i.e. the production of enzymes for the breakdown of plant cell wall components in the form of high polymer carbohydrates [6].

Table 1. *Microbes used in commercial enzyme production.*

Enzyme	Source	Action
α-amylase	Bacillus subtilis Bacillus licheniformis Aspergillusoryzae	Endo-hydrolysis of α-1, 4-glucosidic Linkages
β-glucanase	Bacillus subtilis Aspergillusniger Penicilliumemersonii	Degrades β-glucan by cleavingβ-1,3(4) glucosidic linkages
Pectinase	Aspergillusoryzae Aspergillusniger Rhizopusoryzae	Degrades pectinα-1,4-linked anhydrogalacuronic acid
Pullulanase	Klebsiellaaerogenes	Splits the α-1,6-glycosidic linkages

2.1.3. Classification of Enzyme

According to the purpose of application, feed enzymes can be fundamentally divided in to:

1. Enzymes which are to quantitatively supplement endogenous digestive enzymes of mono gastric animals. Eg. Proteases, lipases, Amylases and

2. Enzymes which are not produced by mono gastric animals Eg. β-glucanases, Pentosanases and Phytases.

2.1.4. Enzyme Stability

i. Animals

For optimum activity an enzyme should be capable of surviving low pH of 2 in stomach and high pH of 6.5 in the intestine. The temperature inside the animal digestive system is significantly lowers than that which causes enzyme in activation.

ii. Feed

Enzymes are stable at 80 – 85°C for 1-2 min as required for pelleting and pH of 5.5 to 6.5 in feed.

2.1.5. Mode of Enzyme Action

Addition of enzymes to feed functions in various ways in birds body thus improving its nutrients utilization and overall performance.

i. Reducing the Gut Viscosity

Cereals contain high proportions of their energy in the form of Non Starch Polysaccharides. Cereals contain soluble indigestible polysaccharides like arabinoxylan (wheat), mixed linked β-glucans (in barley and rye), lignin, and limit dextrin, anti-nutritional factors like phytic acid and cellulose fiber. These NSP are able to bind large amount of water - increasing viscosity in the gut affects rate of passage of digesta - rate of mixing of bile, pancreatic and intestinal secretions with digesta -rate of absorption of digesta - increases the amount of sticky droppings. Addition of suitable multi enzyme preparation improves animal performance in following ways.

Increasing the Effectiveness of Host (Endogenous) Enzymes

Breaking down the gel form characteristic of soluble fibers allows the bird's digestive enzyme to function more efficiently. This improves starch, protein, fat, amino acids and energy digestibility.

Alteration in Feed Passage Rate

The enzymes reduce the water holding capacity of the gut contents thus increasing the dry matter content stimulating feed intake.

Effect on Excreta Characteristics

Addition of enzymes also reduces the dry matter outside the body thus has marked impact on excreta volume and composition. Due to protein digestibility lowering of excreta output is observed.

Effect on Litter Problems

Reduced viscosity improves nutrient digestion, lower water intake and help to reduce litter problems.

ii. Release of Nutrients

Enzymatic de polymerization renders the NSP free releasing nutrients in the gut and it available to the animal. Starch masked by cell structure is released leading to increase in metabolizable energy. Proteins are also released by action of proteases. This release leads to maximum absorption of minerals and results in improvement in nutrient utilization.

iii. Availability of Phosphorus

Cereals and oilseeds contain 1-2% of phytate, and 60-90% of total phosphorus present in the seeds in this phytate phosphorus. Phytase hydrolyses phytic acid to myoinositol and phosphoric acid in step wise manner forming myoinositolphosphatic intermediates (IP5, IP4, IP3, IP2, IP1).

iv. Increase in Available Energy

One of the main reasons for supplementing wheat- and barley-based poultry diets with enzymes is to increase the available energy content of the diet. Increased availability of carbohydrates for energy utilization is associated with increased energy digestibility [7, 8].

The AME of wheat has been extensively studied and found to have a considerable range i.e. 9500–16640 kJ/kg [9, 10, 11, 12, and 13]. Enzyme supplementation improves this range by enhancing carbohydrate digestibility, reducing gut viscosity, and improving fat utilization [3]. The improvements in AME resulting from enzyme supplementation are variable because of the variability in the Non Starch Polysaccharides content of wheat. [14, 15 and 8] reported improvements of 5–16, 3.1–4.5, and 4.5–12.4%, respectively. The increase in AME with the use of enzymes is difficult to predict, as nutrient ratios, such as energy–protein, and other factors also play an important Part in poultry-feed formulations. The AME value of wheat has been correlated with its content of water soluble Non Starch Polysaccharides [16], which in turn affects gut viscosity [17]. Unfortunately, NSP analyses are relatively lengthy processes, and in a commercial situation rapid testing of incoming grains is required. No chemical test or detectable physical characteristic can be used to rapidly predict the AME value of wheat or to estimate the improvements to be expected from the use of enzymes. This is part of the difficulty in trying to accurately estimate the energy content of wheat or barley in poultry feeds and compensate for the deficiency by adding enzymes. Adding adequate activity levels of α-amylase, β-glucanase, and xylanase to broiler starter and grower corn-soybean diets with a 3% reduction in dietary ME allowed full restoration of growth performance of broilers comparable to those fed the adequate energy [18].

v. Improvement in Nutrient Digestibility

Enzymes have been shown to improve performance and nutrient digestibility when added to poultry diets containing cereals, such as barley [19, 20, 21, and 22], maize [23], oats [21], rye [24,25,26, 21,17 and 22], and wheat (25,26, 22] and to those containing pulses, such as lupines[27]. The effect of enzyme supplementation on dry matter digestibilityin pigs and poultry depends on the type of diet and the type of animal: increases in dry matter digestibility range from 0.9 [15] to 17% [16] in poultry. The enzymes currently used in monogastric diets are predominantly glycanases, which cleave Non Starch Polysaccharides SPs into smaller polymers, thereby removing their ability to form viscous digesta and enhancing nutrient digestibility. The effects of glycanases are generally nonspecific, except for their effect on fat (greater effect on saturated fat than on unsaturated fat). Another enzyme used in feed is phytase, which increases the utilization of phytate phosphorus. The ability of phytase to improve the digestion of phytate Phosphorus and subsequently to reduce the output of organic phosphorus to the environment has attracted a great deal of scientific and commercial interest. In poultry use of phytase was reported to reduce phosphorus excretion by as much as 40% for broilers. When phytase was added to layer diets, increased egg production and positive effects on egg weight and tibia ash were also noted [28].

2.1.6. Types of Enzyme Available for Poultry

Some of the enzymes that have been used over the past several years or have potential for use in the feed industry include cellulase (ß-glucanases), xylanases and associated enzymes, phytases, proteases, lipases, and galactosidases (Table 2). Enzymes in the feed industry have mostly been used for poultry to neutralize the effects of the viscous, non-starch polysaccharides in cereals such as barley, wheat, rye, and triticale. These ant nutritive carbohydrates are undesirable, as they reduce digestion and absorption of all nutrients in the diet, especially fat and protein. Recently, considerable interest has been shown in the use of phytase as a feed additive, as it not only increases the availability of phosphate in plants but also reduces environmental pollution. Several other enzyme products are currently being evaluated in the feed industry, including protease to enhance protein digestion, lipases to enhance lipid digestion, ß-galactosidases to neutralize certain anti-nutritive factors in non-cereal feedstuffs, and amylase to assist in the digestion of starch in early-weaned animals [5].

Table 2. *Enzymes Used in Poultry Feeds.*

Enzymes	Substrate	Effect
ß-glucanases	Barley, Oats	Reduction of intestinaldigest viscosity Reduction of dirty egg problems
Xylanases	Wheat, Rye, Triticale Rice bran	Reduction of intestinal digest viscosity
ß-galactosidases	Grain legumes Lupins	Removal of a galactosides
Phytases	Plant feedstuffs	Enhanced utilization of plant phosphorus
Proteases	Proteins	
Lipases	Lipids	
Amylases	Starch	

Source: the role of feed enzymes in poultry nutrition, 2011

2.1.7. Pre-requisite of Enzyme Used in Animal Nutrition

a.Must act under acidic pH condition of stomach
b.Resist low pH
c.Resist pepsin's proteolytic action
d.It should act other parts of digestive tract

For production of enzymes suitable strain and composition of nutritive media should be selected

2.2. Benefits of Enzymes to Poultry

2.2.1. Role of Enzymes to Poultry Nutrition

Poultry do not produce enzymes for the hydrolysis of Non-Starch Polysaccharide present in the cell wall of the grains and they remain un-hydrolyzed. Non Starch Polysaccharides are polymeric carbohydrates which differ in composition and structure from starch [29] and possess chemical cross linking among them therefore, are not well digested by poultry [30, 11]. A part of these Non-Starch Polysaccharides is water-soluble which is notorious for forming a gel like viscous consistency in the intestinal tract [13] thus by reducing gut performance. Predominantly water soluble and viscous arabinoxylans, which belong to pentosan group, are assumed to be the factor responsible. These pentosans also greatly increase the water intake by the birds, which lead to unmanageable litter problems caused by wet and sticky droppings. This deteriorates the hygienic conditions and carcass quality [31]. On the other hand, ß-glucans adversely affect all nutrients, especially protein and starch utilization and are known to give rise highly viscous conditions in the small intestine of the chicks [20]. Research work has suggested that the negative effects of NSPs can be overcome by dietary modifications including supplementation of diets with suitable exogenous enzyme preparations [31]. Enzymes break down the Non Starch Polysaccharides, decreases intestinal viscosity and eventually improve the digestibility of nutrients by improving gut performance. Poultry do not produce enzyme for the hydrolyses of these non-starch polysaccharide present in the cell wall of the grains. Addition of enzymes specific for a given feed formulation will enhance the bioavailability of above feed components. The exogenous enzyme in feed additive can complement to endogenous enzymes in the digestive system during adverse climatic condition and at an early age, to give an increase role of digestion. The production of endogenous enzymes may be a limiting factor due to various reasons depending on the age, health, type of feed, environment etc.

i. Digestibility

- Enhances the feed intake and efficiency, growth rate and productivity.
- Increases the energy value of cereal feed stuffs. More nutrients are made available by hydrolyzing fibrous material.
- Better digestibility of feed ingredients by better feed conversion.
- Enzymes act as supplement to the normal digestive enzymes especially during stress condition.
- Reduces ant nutritional products like tannins, saponin and goitrogen.
- Promotes weight gain and overall improved performance.
- Release minerals for assimilation - eg: Ca, Mg, Zn, P etc.
- Stabilization of microbial flora by making these nutrients readily available to them.
- Checks chelating of minerals such as Zn, Mn, Fe, Ca, K with phytic acid, less chelation means more mineral availability.
- Prevents precipitation of penta calcium phosphate and there by improves absorption of calcium and phosphorus.

ii. Animal Health

[29] Reported that coccidiosis problems could be prevented by using enzymes. Birds fed a wheat-based diet with and without glycanase supplementation showed vastly different responses to coccidiosis challenge. Growth was depressed by 52.5% in the control group but by only 30.5% in the enzyme group, which also had a much better lesion score. An increase in digesta passage rate and a reduction in

excreta moisture are often noted when glycanases are added to poultry diets, which may be detrimental to the life cycle of the organism. It's also used as:-

- Improvement in animal hygiene and health
- Corrects digestive disorders especially when birds are crowded.
- Fattening performance is increased.
- Prevents damages to chicken anemia agent.
- Checks cellular damages caused by toxins.
- Promotes growth to bones.
- Prevents diarrhea due to poor fiber digestion.
- Minimizes excreta, water droppings and of ammonia.
- Reduces viscosity and ammonia level in intestine.

iii. Poultry product

- Increases egg production and hatchability in layers.
- Egg quality is also maintained.
- More cleanly eggs and with thick shell is maintained.
- Improves flock uniformity leading to more consistent sized birds.
- Improved slaughter results, high carcass weights and better grading.
- Genetic Potential of birds can be explored enabling them to consume more quality of feed to achieve maximum growth and production.

iv. Increased Precision and Flexibility in Least Cost Feed Formulation

An increased precision in least cost feed formulation, hence a more uniform performance of the birds. Enzymes also allow a wide range of ingredients to be used in a diet with a desired outcome. This gives the producer a great deal of flexibility to formulate a nutritionally balanced least-cost diet.

2.2.2. Benefits of Enzymes to Environment

Enzymes have been approved for use in poultry feed because they are natural products of fermentation and therefore pose no threat to the animal or the consumer. Enzymes not only will enable livestock and poultry producers to economically use new feedstuffs, but will also prove to be environmentally friendly, as they reduce the pollution associated with animal production. As well as contributing to improved poultry production, feed enzymes can have a positive impact on the environment. In areas with intensive poultry production, the phosphorus output is often very high, resulting in environmental problems such as eutrophication. This happens because most of the phosphorus contained in typical feedstuffs exists as the plant storage form phytate, which is indigestible for poultry. The phytase enzyme frees the phosphorus in feedstuffs and also achieves the release of other minerals (e.g. Ca, Mg), as well as proteins and amino acids bound to phytate. Thus, by releasing bound phosphorus in feed ingredients, phytase reduces the quantity of inorganic phosphorus needed in diets, makes more phosphorus available for the bird, and decreases the amount excreted into the environment [28]. Therefore benefits of enzymes to environment:-

a.Reduction in manure volume: -wet excreta leads to dirty eggs and they are not suitable for sale as second – grade eggs. Wet droppings may also cause increased gas production (i.e. ammonia) and fly and rodent population in the shed. Wet dropping can also affect the health of the staff working in the shed.

b.Reduced nitrogen and Phosphorus exertion.

c.Less environmental waste and therefore less pollution.

d.Reduced environmental stress resulting from reduced litter volume.

2.2.3. Use of Enzymes in Feed

Enzymes provide greater flexibility in feed formulation and allow the use of a wide range of ingredients without compromising bird performance and hence provide great flexibility in least-cost feed formulation. The nutritive value of cereal grains for poultry varies greatly, and no suitable assays are currently available for rapid in-mill testing. For instance, the variability in the AME of wheat for poultry can be as great as 4 MJ/kg dry matters[10]. This problem can be largely overcome by using glycanases to bring the AME of different wheats to comparable levels [12].

- To enhance the feed intake and efficiency growth rate & productivity, by overcoming many nutritional problems and correcting digestive disorders especially when birds are crowded.
- To increase the energy value of cereal feedstuffs. More nutrients are made available by hydrolyzing fibrous material
- To minimize excreta, watery dropping and ammonia
- To reduce anti-nutritional products like tannins, saponins and goitrogens
- To provide choice of raw materials. For e.g. Barley, which was not earlier used, is now successfully used with enzymes.
- To promote faster growth by increasing feed efficiency and promoting weight gain
- To increase egg production and hatchability in layers
- To reduce early mortality due to the problems associated with harmful moulds and aflatoxin in poultry feeds.
- Enzyme-added feed provide additional option where certain feedstuffs are in short supply
- Readily available materials can be advantageously utilized
- Price advantage over more traditional and inexpensive feedstuffs can be taken
- As growth promoters, feed enzyme additives hold promise to lower the overall production costs while improving the performance of birds
- The genetic potential of birds can be explored, enabling them to consume more quality of feed to achieve maximum growth and production.

2.3. Factors Affecting the Benefits of Enzyme as Poultry Feed

The degree of improvement obtained by adding enzymes to the diet depends on many factors [17], including the type

and amount of cereal in the diet, the level of anti-nutritive factor in the cereal which can vary within a given cereal (for example, low- versus high-ß-glucan barley), the spectrum and concentration of enzymes used, the type of animal (poultry tend to be more responsive to enzyme treatment than pigs), and the age of the animal (young animals tend to respond better to enzymes than older animals), type of gut micro flora present and the physiology of the bird. Older birds, because of the enhanced fermentation capacity of the micro flora in their intestines, have a greater capacity to deal with negative viscosity effects [31, 12, and 32]. Use of enzymes in layers the majority of research trials were conducted on broilers. However, the responses of laying hens to enzyme-supplemented feeds are also well documented. Typically, enzymes added to layer feed appear to have little effect on egg mass but improve feed efficiency [33, 32] energy utilization [34].[34]Reported that corn-fed layers exhibited better feed efficiency than those fed enzyme supplemented barley-based diets. Nevertheless, enzyme supplementation improved the utilization of barley diets. Increased energy utilization in laying hens appears to be due to microbial fermentation of solubilized Non Starch Polysaccharides and the subsequently higher absorption of volatile fatty acids [12]. Wet litter arising from the use of barley and newly harvested wheat can result in an increased incidence of dirty egg shells and in ammonia build up in poultry barns. Adding enzymes to both wheat and barley-based diets has been shown to reduce the moisture content of fecal matter in layers [22].

3. Conclusions

It is now well recognized that ingredients such as maize, soybean and, particularly, grain byproducts contain relatively high levels of dietary fiber and that this fiber has negative impacts on feed digestibility and performance. This allows for the option of using the enzyme to improve growth and feed gain or, alternatively, to use it in diets with lowered levels of energy and protein/amino acids, with higher by-product levels, to maintain performance with lower net feed costs.

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