

Pemanfaatan Enzim untuk Formulasi Pakan Unggas yang Optimal (Ulasan Pendek)

Harnessing Enzymes for Optimal Poultry Feed Formulations (Mini Review)

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ABSTRAK

Makalah ini berfokus pada penggunaan enzim dalam formulasi pakan unggas yang efektif dan efisien. Pendahuluan menyoroti pentingnya nutrisi yang baik untuk unggas dan meningkatnya kebutuhan akan formulasi pakan yang inovatif karena ketersediaan yang terbatas dan kenaikan harga bahan pakan. Enzim diperkenalkan sebagai senyawa protein yang meningkatkan pencernaan dan penyerapan nutrisi pada unggas, berpotensi mengurangi biaya produksi pakan. Namun, penggunaannya secara luas di Indonesia masih terbatas karena kurangnya pengetahuan. Makalah ini membahas peran enzim dalam nutrisi unggas, termasuk keterlibatannya dalam pencernaan dan penyerapan nutrisi. Ini juga menekankan nutrisi penting yang dibutuhkan untuk pertumbuhan dan perkembangan unggas dan faktor-faktor yang mempengaruhi kebutuhan nutrisi mereka. Jenis-jenis enzim yang biasa digunakan dalam formulasi pakan unggas, seperti fitase, amilase, protease, dan lipase, dieksplorasi bersama dengan mekanisme kerjanya. Temuan penelitian menunjukkan efektivitas dan efisiensi penggunaan enzim dalam meningkatkan ketersediaan nutrisi dan efisiensi pakan, yang pada akhirnya meningkatkan produktivitas dan keberlanjutan produksi unggas. Makalah ini diakhiri dengan rekomendasi untuk pengembangan dan penerapan enzim dalam formulasi pakan unggas, menyoroti perlunya pemilihan enzim yang cermat, penyesuaian dosis, dan pertimbangan kondisi lingkungan. Selanjutnya, pentingnya mengintegrasikan enzim dengan bahan pakan lain dan mengadopsi strategi nutrisi yang komprehensif ditekankan. Secara keseluruhan, penggunaan enzim dalam formulasi pakan unggas menawarkan keuntungan yang signifikan untuk peternakan unggas modern, tetapi implementasi yang cermat dan penelitian lebih lanjut diperlukan untuk mengoptimalkan efektivitas dan efisiensinya.

Kata kunci: Enzim, Pakan, Kesehatan unggas.

ABSTRACT

This paper focuses on the use of enzymes in effective and efficient poultry feed formulations. The introduction highlights the importance of good nutrition for poultry and the increasing need for innovative feed formulations due to limited availability and rising prices of feed

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ingredients. Enzymes are introduced as protein compounds that enhance nutrient digestion and absorption in poultry, potentially reducing feed production costs. However, their widespread use in Indonesia is still limited due to a lack of knowledge. The paper discusses the role of enzymes in poultry nutrition, including their involvement in digestion and nutrient absorption. It also emphasizes the essential nutrients required for poultry growth and development and the factors influencing their nutritional needs. The types of enzymes commonly used in poultry feed formulations, such as phytase, amylase, protease, and lipase, are explored along with their mechanisms of action. Research findings demonstrate the effectiveness and efficiency of using enzymes in improving nutrient availability and feed efficiency, ultimately enhancing poultry production productivity and sustainability. The paper concludes with recommendations for the development and application of enzymes in poultry feed formulations, highlighting the need for careful enzyme selection, dosage adjustment, and consideration of environmental conditions. Furthermore, the importance of integrating enzymes with other feed ingredients and adopting a comprehensive nutrition strategy is emphasized. Overall, the use of enzymes in poultry feed formulations offers significant advantages for modern poultry farming, but careful implementation and further research are necessary to optimize their effectiveness and efficiency.

Keywords: Enzymes, Feed, Poultry health.

INTRODUCTION

Feed is one of the important factors in the success of poultry farming. Good feed must meet the nutritional needs needed by poultry and must be easily digested and absorbed by the poultry body (Bailey, 2019; Gupta et al., 2022). In recent years, the need for poultry feed has increased, while the availability of feed ingredients is increasingly limited and the price is getting more expensive. This causes farmers to look for innovations in effective and efficient poultry feed formulations.

One of the innovations that has been developed in the formulation of poultry feed is the use of enzymes. Enzymes are protein compounds that function to accelerate chemical reactions in the poultry body, especially in the digestion and absorption of nutrients. The use of enzymes in poultry feed formulations can increase the availability of nutrients in feed and lower feed production costs (Menezes-Blackburn & Greiner, 2015; Pettersson & Åman, 1989; Ravindran, 2013; L. F. Romero, 2014).

However, the use of enzymes in poultry feed formulations is still not massively applied in Indonesia. This may be due to a lack of knowledge and understanding of the use of enzymes in poultry feed formulations. Therefore, research on the use of enzymes in effective and efficient poultry feed formulations is very important to be carried out, to increase productivity and efficiency in poultry cultivation in Indonesia. This paper will discuss poultry nutrition innovations, especially the use of enzymes in effective and efficient poultry feed formulations.

This article explains the importance of good nutrition for poultry and explains what enzymes are and their role in digestion and nutrient absorption in poultry. The essential actions required for poultry growth and development are also described, along with factors

affecting poultry nutritional needs. In addition, the types of enzymes commonly used in poultry feed formulations and the mechanism of their use in supporting nutrient absorption, based on the latest research results are also reviewed to reveal the effectiveness and efficiency of using enzymes in poultry feed formulations, especially in increasing poultry production productivity and efficiency. The end of this review recommends strategies for the development and application of enzymes in poultry feed formulations to increase the productivity and efficiency of poultry production sustainably.

POULTRY NUTRITION AND THE ROLE OF ENZYMES

1) The importance of good nutrition for poultry

Good nutrition is essential for poultry as it plays a key role in their health, growth, and productivity. Adequate and balanced nutrition helps maintain the immune system of poultry, increase feed efficiency and growth, as well as increase the production of quality eggs and meat. (Aaron J. Cowieson & Adeola, 2005).

Nutritional deficiencies in poultry can lead to various health and productivity problems (Jensen, 2000). For example, protein deficiency can inhibit egg growth and production, while mineral deficiency can lead to bone and quail disease. Vitamin A deficiency can cause health problems in the eyes and respiratory system, while vitamin D deficiency can inhibit calcium and phosphorus absorption, which can lead to bone disease (Applegate & Angel, 2008).

In addition, an excess of certain nutrients can also harm the health and productivity of poultry. For example, excess fat in poultry feed can lead to obesity and related health problems, such as decreased egg and meat quality, and excess calcium in feed can lead to disruption of the poultry reproductive system (Bernardino et al., 2015).

To avoid a lack or excess of nutrients in poultry, the farmer should choose quality feed and pay attention to the composition of nutrients in the feed. The nutritional intake of poultry should include all the required nutrients in the right amount and can be regulated based on the stage of poultry production and their state of health. The use of nutritional supplements can also help improve nutrient intake in poultry and increase their productivity (Bao et al., 2013; Clssen & Bedford, 1991).

Several studies have shown that providing balanced and proper nutrition to poultry can improve their growth, health, and productivity (Pandey et al., 2019). For example, research by (Kiarie et al., 2013) shows that proper nutrition in poultry can promote weight gain and better feed conversion. Likewise, studies by (Kyriliv et al., 2018) show that providing proper nutritional intake in quails can improve growth, egg weight, and egg quality.

To provide a balanced nutritional intake in poultry, it is also necessary to supervise the quality of feed and feed raw materials used. This is because poor and unbalanced feed quality can adversely affect the health and productivity of poultry. Therefore, farmers need to choose quality feed and ensure that the feed raw materials used are free from contamination and have appropriate nutrition.

2) Enzymes and their Role in poultry digestion

The enzymes commonly used in poultry feed are digestive enzymes that can help break down nutrients in feed and increase the availability of nutrients for use by poultry (Anadón et al., 2019; Ojha et al., 2018; Ravindran, 2013; Sheppy, 2001). Some enzymes that are often used in poultry feed include phytase, amylase, protease, and lipase. The use of these enzymes in poultry feed can improve digestion and absorption of nutrients in poultry, to improve poultry growth and health. Some studies have also shown that the use of enzymes in poultry feed can reduce feed production costs and increase feed efficiency.

Phytase is one of the most commonly used enzymes in poultry feed. This enzyme plays a role in breaking down inorganic phosphate contained in phytates, a complex organic compound found in grains and legumes (Hafsan, Nurhikmah, et al., 2018). By breaking down phytase can increase the availability of phosphorus in poultry feed. Higher phosphorus availability can help promote poultry growth and reduce phosphorus waste in the environment (A. Cowieson et al., 2013; Purnamasari & Miswar, 2018).

In addition, other enzymes such as amylase play a role in breaking down carbohydrates, proteases play a role in breaking down proteins, and lipase plays a role in breaking down fats. These enzymes can help increase the availability of nutrients in feed and increase feed efficiency in poultry.

Several studies have shown that the addition of digestive enzymes in poultry feed can improve poultry performance and increase the availability of nutrients in feed. For example, a study by (Rutherford et al., 2012) showed that the addition of phytase to broiler feed can increase the availability of phosphorus in feed and promote chicken growth. Another study that supports the importance of feeding enzymes in poultry feed is a study by Józefiak and colleagues in 2010. The study showed that the administration of amylase feed enzymes and proteases in broiler chicken feed can improve the digestion of protein and fat in feed, and increase chicken growth.

Studies conducted by (Pedersen et al., 2012) show that the application of protease enzymes in poultry feed can increase feed conversion and increase broiler body weight. Another study conducted by (Castro & Kim, 2021) showed that giving lipase in poultry feed can improve fat digestibility and production performance in laying hens.

POULTRY NUTRITIONAL NEEDS

1) Essential nutrients for the growth and development of poultry

Essential nutrients are nutrients needed by poultry to meet the basic needs of the body and maintain optimal health, growth, and development. Essential nutrition for poultry consists of proteins, carbohydrates, fats, vitamins, minerals and water. Lack or excess of essential nutrients can significantly affect poultry health and productivity (Castro & Kim, 2021).

Protein is an essential nutrient that is very important for poultry, because protein is needed for the growth and development of the body, including muscles and bones. Protein also plays an important role in egg production and poultry reproduction (Bernardino et al., 2015). Carbohydrates and fats are also important sources of energy for poultry.

Carbohydrates are mainly needed as a source of quick energy, while fats are a longer source of reserve energy. In addition, vitamins and minerals are also essential nutrients for poultry. Vitamins and minerals are needed in smaller amounts, but they are essential for maintaining the health and functionality of the body. Vitamins and minerals are involved in many biochemical reactions in the poultry body and help keep the immune system healthy and optimal. Water is also an essential nutrient for poultry because it is essential for the health and functioning of the body. Water is needed to regulate body temperature, maintain fluid balance in the body, and help the digestive and metabolic processes in supporting poultry growth (Jin et al., 1998).

In general, the essential nutritional needs of poultry can differ depending on the type of poultry, age, sex, and production phase. The essential nutritional needs of poultry must be met through proper feeding with an appropriate composition. Several studies have shown that deficiencies in essential nutrients can affect poultry growth and development, as well as poultry productivity and health. For example, protein deficiency in poultry can lead to slow growth, whereas vitamin and mineral deficiencies can lead to health problems such as bird stress and a weakened immune system. In principle, essential nutrients are very important for the optimal growth and development of poultry. Proper feeding with appropriate nutritional composition can help meet the essential nutritional needs of poultry and improve poultry health and productivity (Aaron J. Cowieson & Adeola, 2005).

2) Factors affecting the nutritional needs of poultry

The nutritional needs of poultry are influenced by several factors, such as poultry type, age, sex, production phase, environment, and genetics (Aaron J. Cowieson & Adeola, 2005; Greenhalgh, 1997; Gupta et al., 2022; He et al., 2021). Understanding these factors is essential for compiling appropriate feed and meeting the nutritional needs of poultry.

- **Type of Poultry:** The type of poultry affects their nutritional needs. For example, broilers have different nutritional needs than laying hens. Broilers require a diet higher in protein and energy while laying hens require a diet higher in calcium.
- **Age:** The nutritional needs of poultry are also influenced by their age. Early in life, poultry needs a diet higher in protein and energy for optimal growth and development. In the adult production phase, poultry nutritional needs tend to decrease.
- **Gender:** The sex of poultry also affects their nutritional needs. For example, roosters need a diet higher in protein and energy to maintain greater muscle mass.
- **Production Phase:** The nutritional needs of poultry are also influenced by their production phase. For example, in the egg production phase, poultry needs a diet higher in calcium to help the formation of a strong eggshell.
- **Environment:** The environment in which poultry live can also affect their nutritional needs. For example, in cold environments, poultry requires a higher energy diet to maintain their body temperature.
- **Genetics:** The genetics of poultry also affect their nutritional needs. Some strains of poultry have different nutritional needs than other strains of poultry.

In practice, the nutritional needs of poultry should be carefully determined and adjusted to the above factors. The use of the right feed with nutritional content that is to the needs of poultry can help meet their nutritional needs and improve their health and productivity.

ENZYMES USED IN POULTRY FEED FORMULATIONS

1) Phytase breaks down phytate anti-nutritional compounds

Phytase is a type of enzyme responsible for breaking down phytate compounds (inorganic phosphates) in poultry feed (Hafsan et al., 2020). These phosphate compounds are generally bound to proteins, carbohydrates, and fats contained in poultry feed and are difficult to digest by the poultry digestive system, so they are considered anti-nutritional compounds. With the help of phytase, phosphate compounds can be broken down into simpler forms and easily absorbed by the poultry body. Table 1 describes some research results that report the use of phytase in feed for various types of poultry. The mechanism of phytase in helping poultry digest feed can be explained as follows:

- Helps the breakdown of phosphate compounds: phytase works by removing phosphate bonds from complex compounds in poultry feed, such as proteins, carbohydrates, and fats. Once the phosphate is released, the compound becomes more easily digested by other digestive enzymes.
- Increase nutrient availability: by aiding the breakdown of phosphate compounds in poultry feed, phytase also increases nutrient availability for poultry. Phosphate compounds that have been broken down can be absorbed more efficiently by the poultry body and used for the growth and development of the body.
- Improve feed efficiency: Under normal conditions, most of the phosphate compounds in poultry feed will be wasted without being digested by poultry and polluting the surrounding environment. By using phytase, phosphate compounds can be broken down and utilized by the poultry body optimally, to increase feed efficiency.

Table 1. Utilization of phytase in the feed of various types of poultry

No.	Types of poultry	Study Results
1	Laying hens	Feeding phytase in laying hen feed increases feed consumption, body weight and egg production (Agunbiade et al., 2021).
2	Broiler	Feeding phytase in broiler feed increases the growth and efficiency of broiler feed (Woyengo et al., 2010).
3	Pecking ducks	Phytase feeding of laying ducks increases the availability of phosphorus and the productivity of laying ducks (Orban et al., 1999).
4	Japanese quail	Fitase feeding of Japanese quail increases the availability of nutrients and growth (Rossetto et al., 2019).

Phytase can be given to poultry feed in supplement form or produced through the feed fermentation process. The use of phytase in poultry feed has been shown to increase the availability of phosphates and other nutrients, as well as increase poultry productivity.

Therefore, the use of phytase in poultry feed is very important to ensure optimal and efficient nutrition for poultry growth and development (Hafsan, Bayu, et al., 2018; Hafsan et al., 2020).

2) Amylase enzyme to break down complex carbohydrates

Amylase is an enzyme that plays a role in digesting carbohydrates, especially amylum. Amylum is one type of complex carbohydrate found in many poultry feed ingredients, such as corn, wheat, and soybeans. Amylum digestion begins in the mouth with the help of saliva containing the enzyme amylase. After the feed ingredients are digested in the mouth, they feed ingredients will enter the stomach, which is the place where the feed ingredients are further digested (Ariandi, 2016).

In the stomach, a low pH will stimulate the release of the hormone gastrin, which in turn will trigger the release of pancreatic enzymes, including amylase. Amylase produced by the pancreas will enter the small intestine, where the process of digestion of carbohydrates continues. Amylase will break down amylum into smaller glucose molecules, making it easier for poultry to digest. Glucose produced from this digestive process will be absorbed by the small intestine and used by poultry as an energy source. However, some poultry, such as chickens and ducks, have limited amylase activity. Therefore, feed supplementation with extra amylase enzyme can help improve carbohydrate digestion and maximize nutrient availability for poultry (Duarte et al., 2014).

Some studies show that feed supplementation with amylase enzyme can increase nutrient availability for poultry and reduce excess nutrients in poultry manure. For example, a study by Onderci and colleagues (2006) showed that supplementation of broiler chicken feed with amylase enzyme increased feed conversion and increased body weight.

Table 2. Utilization of Amylase in the feed of various types of poultry

No.	Types of poultry	Study Results
1	Brazilian chickens	Improves digestibility of cornstarch (Gernaey et al., 2018).
2	Turkey	Increase body weight and feed conversion ratio (Bampidis et al., 2020).
3	Duck	Increase feed consumption and digestibility of nutrients (Chen et al., 2021)
4	Laying hens	Improves digestibility of energy and protein in rations (Choct et al., 2010)

3) Protease enzymes break down proteins

Proteases are enzymes that help poultry digest the protein in their feed. Proteases are produced by poultry digestive glands such as the stomach, small intestine, and pancreas. Protease enzymes work by breaking peptide bonds in proteins into smaller amino acids. This allows poultry to absorb essential nutrients such as amino acids and peptides into their digestive systems (López-Otín & Bond, 2008).

The mechanism of action of proteases in the digestion of poultry begins when food enters the stomach. In the stomach, the acidic pH helps proteases to activate themselves and break down proteins. Next, the digested food passes into the small intestine, where proteases from the pancreas are involved in further protein digestion.

The proteases contained in the pancreas are activated by the hormone gastrin produced by digestive cells in the stomach wall. Once activated, the protease will be transported into the small intestine through the digestive tract. There, protease enzymes will break down proteins into smaller amino acids so that they can be absorbed by the small intestine and enter the poultry bloodstream.

Some types of proteases that are important in poultry digestion include trypsin, chymotrypsin, and carboxypeptidase. Each type of protease has a different specificity in breaking peptide bonds in proteins. In addition, factors such as pH and temperature can also affect the effectiveness of proteases in digestion.

In poultry feed formulations, the addition of proteases to feed can help improve protein digestion and the availability of essential nutrients such as amino acids (Razzaq et al., 2019). Various studies have been conducted to evaluate the effectiveness of protease utilization in poultry feed. Various studies show that the addition of proteases to poultry feed can increase the availability of amino acids and increase poultry growth (Borda-Molina et al., 2019; Koryagina et al., 2019; Murugesan et al., 2014), as in Table 3.

Table 3. Utilization of Protease in the feed of various types of poultry

No.	Subject	Study Results
1	Broiler	Increase body weight and feed efficiency (Borda-Molina et al., 2019).
2	Quail	Increases retention of nitrogen and amino acids in the body (Diana et al., 2019)
3	Broiler	Increase feed consumption and protein retention (Murugesan et al., 2014)
4	Duck	Increase feed consumption and growth (Jiang et al., 2020)

4) Lipase enzyme to break down fat

Lipase is an enzyme that helps the breakdown of fat in poultry feed into fatty acids and glycerol so that the nutrients contained in the fat can be better digested and absorbed by the poultry body. Lipase is produced by the pancreas gland of poultry and released into the digestive tract when food has reached the small intestine. However, a lack of lipase in feed can cause fat to be poorly digested and lead to low feed efficiency and nutrient absorption.

The addition of lipase to poultry feed can increase the ability of poultry to digest fat and absorb nutrients contained in fat. Lipase can be added to poultry feed in powder or liquid form. The mechanism of adding lipase to feed can increase enzyme activity in the digestive tract of poultry and help the breakdown of fat into fatty acids and glycerol. In this process, lipase binds to the fat substrate and breaks it down into small molecules that are easier for the poultry body to digest and absorb. This process can also increase the availability of nutrients contained in fat and increase feed efficiency.

Several studies have shown that the addition of lipase to poultry feed can improve egg production performance, health, and quality (Table 4). However, the dose and form of lipase added need to be adjusted to the type of feed and nutritional needs of poultry.

Table 4. Utilization of Lipase in the feed of various types of poultry

No.	Subject	Study Results
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1	Pecking ducks	Improves the digestibility of fats and fatty acids in feed (Khattab et al., 2021).
2	Laying hens	Increase egg production, and hatchability and also maintain egg quality (Shitaneh & Abu, 2019).
3	Broiler	Increase body weight, feed efficiency, and nutrient digestibility (De Oliveira et al., 2019).

EFFECTIVENESS AND EFFICIENCY OF ENZYMES IN POULTRY FEED FORMULATION

1) Increase the effectiveness and efficiency of poultry feed by

Proper and high-quality feed is one of the key factors in the growth and productivity of poultry livestock. Enzymes are protein catalysts that accelerate chemical reactions in poultry digestion and can increase the effectiveness and efficiency of poultry feed. The four main types of enzymes used in poultry feed are phytase, amylase, protease, and lipase.

The utilization of phytase in poultry feed is very important because it can increase the absorption of phosphorus and other minerals contained in the feed. The use of phytase in poultry feed can reduce the amount of phosphorus in the feed needed by poultry, thereby reducing production costs. Several studies have shown that the utilization of phytase in poultry feed can improve poultry growth and reproductive performance, as well as reduce the amount of phosphorus removed in poultry manure, thereby reducing the environmental impact of the livestock industry (A. Cowieson et al., 2013; Purnamasari & Miswar, 2018).

Amylase is an enzyme that helps in the digestion of complex carbohydrates in poultry, which will then be converted into energy for growth and egg production. The use of amylase in poultry feed can improve feed efficiency and poultry growth. Several studies have shown that the utilization of amylase in poultry feed can increase body weight and feed conversion in broiler chickens, thereby reducing production costs and increasing feed efficiency (A. J. Cowieson et al., 2019; Kaczmarek et al., 2014; Liu et al., 2020; Onderci et al., 2006).

Proteases are enzymes that help in protein digestion in poultry. The use of proteases in poultry feed can increase feed effectiveness, reduce protein waste, and promote poultry growth. Several studies have shown that the use of proteases in poultry feed can increase body weight, feed conversion, and feed efficiency in broiler chickens, thereby reducing production costs and increasing productivity (Aaron J. Cowieson & Adeola, 2005; Lin Law et al., 2019; Moreira et al., 2020; Oxenboll et al., 2011; Pedersen et al., 2012; Philipps-Wiemann, 2018; L. F.; Romero & Plumstead, 2013).

Lipase is an enzyme that helps in the digestion of fat in poultry. The use of lipase in poultry feed can increase feed effectiveness, reduce fat waste, and promote poultry growth. Several studies have shown that the utilization of lipase in poultry feed can increase body weight, feed conversion, and feed efficiency in broiler chickens, thereby reducing production costs and increasing productivity (Arshad et al., 2021; Castro & Kim, 2021).

With the use of these four types of enzymes, the efficiency of poultry feed can be improved, thereby reducing production costs. In the modern livestock industry, the cost of feed is one of the largest costs in poultry production. Therefore, increased feed efficiency can help farmers reduce production costs and increase profits. The use of enzymes can also

increase poultry productivity, by estimating the amount of nutrient absorption and optimal use of feed (Anadón et al., 2019; Bailey, 2019; Bedford & Apajalahti, 2022; Duarte et al., 2014; Ojha et al., 2018; Pandey et al., 2019; Pedersen et al., 2012; Philipps-Wiemann, 2018; Pirgozliev et al., 2019; Ravindran, 2013; L. F. Romero, 2014; Sheppy, 2001).

In the modern livestock industry, the use of enzymes in poultry feed can help farmers improve feed efficiency, reduce production costs, and increase poultry productivity. In addition, the use of enzymes in poultry feed can also help reduce poultry manure waste that contains undigested nutrients. However, farmers must still be careful in the use of enzymes and ensure the right dosage so that side effects do not occur in poultry.

2) Factors affecting the effectiveness and efficiency of enzyme use

Several factors affect the effectiveness and efficiency of using enzymes in poultry feed.

- The quality of the enzymes used is very important to ensure effectiveness and efficiency in the digestion of poultry feed. The quality of enzymes can be affected by the production process, purity, stability, and activity of those enzymes.
- The level of enzyme inclusion in feed The level of enzyme inclusion in poultry feed can affect the effectiveness and efficiency of its use. If the rate of inclusion of enzymes is too low, then enzymes will not meet the needs of poultry and are not effective in aiding the digestion of feed. Conversely, if the enzyme inclusion rate is too high, then production costs will increase and may reduce production efficiency.
- Quality of Feed Raw Materials The quality of feed raw materials, such as crude fibre and protein content, can affect the effectiveness and efficiency of enzyme use. Raw materials that are high in crude fibre will be difficult for poultry to digest, so the use of enzymes can help break down the fibre and increase the efficiency of feed digestion. In addition, protein quality can also affect the effectiveness of protease enzymes in feed protein digestion.
- Different types of poultry have different nutritional needs. Therefore, the effectiveness and efficiency of the use of enzymes in poultry may vary depending on the type of poultry. For example, birds with complex digestive systems such as broiler chickens may require more enzymes than birds with simpler digestive systems such as quails.
- Optimal pH and Temperature Enzymes have different optimal pH and temperatures depending on the type of enzyme. Therefore, to ensure the effectiveness and efficiency of enzyme use, the pH and temperature of the environment must be maintained at optimal levels.
- Interaction between enzymes and other nutrients in feed can affect the effectiveness and efficiency of enzyme use. For example, the use of protease enzymes can increase the efficiency of protein digestion, but if there is an excess of amino acids in the feed, then the use of these enzymes will not be effective.

By paying attention to these factors, the use of enzymes in poultry feed can be more effective and efficient in increasing poultry productivity and reducing production costs. Therefore, the use of enzymes in poultry feed can be an effective strategy to increase poultry production and profits for farmers. In addition, the use of enzymes in poultry feed can also help in reducing the environmental impact caused by livestock waste (A. J. Cowieson & Klünter, 2019; Gupta et al., 2022; Menezes-Blackburn & Greiner, 2015; Pirgozliev et al., 2019).

ADVANTAGES AND CHALLENGES OF USING ENZYMES IN POULTRY FEED FORMULATIONS

The use of enzymes in poultry feed formulations has various advantages, among which increases the effectiveness and efficiency of feed, as well as reduces production costs. In the modern livestock industry, the cost of feed is one of the largest costs in poultry production. Therefore, increased feed efficiency can help farmers reduce production costs and increase profits. The use of enzymes can also increase poultry productivity, by maximizing nutrients in feed and improving poultry health.

However, there are some challenges in the use of enzymes in poultry feed formulations. First, improper use of enzymes can produce inconsistent or even poor results and can reduce poultry productivity. Secondly, the availability of high-quality and stable enzymes on the market can be challenging, as there are many different types of enzymes with varying degrees of stability. Third, improper use of enzymes can lead to imperfect digestion and poultry health problems, such as diarrhoea and other digestive problems. Therefore, the use of enzymes in poultry feed formulations should be carried out carefully and supported by careful research. The use of enzymes should be selected based on the type of feed used, and the amount of enzymes given should be appropriately regulated to ensure optimal effectiveness and efficiency. In addition, the availability of high-quality and stable enzymes must also be considered to ensure the consistency and safety of the poultry feed produced.

In terms of the development and use of enzymes in poultry feed formulations, there are still many opportunities for research and innovation. For example, the development of more effective and efficient technologies for enzyme production, further research on the mechanisms of enzymes in poultry digestion, and the development of specialized poultry feed designed to maximize the use of enzymes.

The use of enzymes in poultry feed formulations can bring significant advantages to modern farms but must be balanced carefully and with the support of careful research. With the development of technology and innovation that continues to develop, the use of enzymes in poultry feed production can continue to be increased to produce better and more efficient results.

CONCLUSION AND RECOMMENDATIONS

In the use of enzymes in poultry feed formulations, several recommendations need to be considered to ensure the effectiveness and efficiency of their use. The following are some recommendations for the effective and efficient use of enzymes in poultry feed formulations:

- Choosing the right enzymes: Before choosing the enzymes to use, the farmer should consider the type of feed to be given to poultry, as well as the degree of digestion of poultry to the feed. By choosing the right enzymes, the effectiveness and efficiency of their use can be improved.
- Adjusting the dose of enzymes: The farmer should pay attention to the dosage of enzymes given in poultry feed. Too few enzymes will not have a significant effect, while too many enzymes can cause damage to the feed. Therefore, the dose of enzymes must be adjusted to the needs and type of feed given.

- Pay attention to environmental conditions: Enzymes can be degraded by environmental conditions such as temperature, pH, humidity, and so on. Therefore, the farmer must pay attention to the environmental conditions in which the feed is stored, as well as the environmental conditions inside the digestive system of poultry.
- Using stable enzymes: Enzymes that are stable under certain environmental conditions can increase the effectiveness and efficiency of their use. Breeders can choose enzymes that have high stability at different temperatures and pH.
- Combining enzymes with other feed ingredients: Enzymes do not work optimally if used alone without other feed ingredients. Therefore, farmers should consider the combination of enzymes with other feed ingredients such as organic acids, prebiotics, and probiotics to increase the effectiveness and efficiency of their use.
- In the use of enzymes in poultry feed formulations, keep in mind that the use of enzymes is not a single solution to increase the effectiveness and efficiency of feed. The use of enzymes should be considered as part of a comprehensive and integrated nutrition strategy. Farmers must also pay attention to other factors such as feed ingredient quality, livestock management, and environmental conditions to achieve optimal results in poultry production.

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