Protein products in poultry nutrition

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Abstract: In poultry nutrition, most attention is given to protein products, due to the importance of protein as a major constituent of the biologically active compounds in the body. It also assists in the synthesis of body tissue, for that renovation and growth of the body. Furthermore, protein exists in form of enzymes and hormones which play important roles in the physiology of any living organism. Broilers have high dietary protein requirements, so identification of the optimum protein concentration in broiler diets, for either maximizing broiler performance or profit, requires more knowledge about birds' requirements for protein and amino acids and their effects on the birds' growth performance and development. The broad aim of this review is to highlight the importance of some of the available high-quality specialized protein products of both animal and plant origins which can be explored for feeding broiler chickens. Feeding these products to broiler chicks, especially at an earlier age, can assist early gut development and digestive physiology, and improve broiler growth performance and immunity.

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Introduction

Broiler chicks have been shown to benefit from immediate access to feed. Although the focus of nutrition has been on provision of energy, chicks would benefit from a more balanced nutrient profile, particularly protein and amino acids (Kleyn and Chrystal, 2008). Therefore advances in nutrition will be fundamental to securing this rapid growth achievement and maintaining sustainable broiler production. Accordingly, the common focus of nutrition, to simply supply nutrients for maintenance and growth has become obsolete. Specialist areas such as immuno-nutrition, are rapidly gaining attention (Field et al., 2000, Okamoto et al., 2009). Therefore during broiler diet formulation, choosing ingredients to maximize nutrient availability, rather than simply meeting energy or amino acid levels, is necessary (Ravindran, 2005). When formulating broiler diets, the main emphasis is placed on the crude protein (CP), because protein is the critical constituent of poultry diets, and together with the other main nutrients such as carbohydrates, fat, water, vitamins, and minerals, is essential for life (Cheeke, 2005). Proteins are polymers that are composed of α-amino acids, which are linked together by peptide bonds. Proteins are broken down and hydrolyzed in the digestive system into amino acids. Then, after absorption, the amino acids will be assembled and metabolized to form proteins that are used in the building of different body tissues (Aviagen, 2009). They also serve vital metabolic roles as blood plasma proteins, enzymes, hormones, and antibodies, each of which has a specific role in the body (Pond et al., 1995).

Sources of protein for poultry

In poultry feed formulation, after the energy-yielding raw materials, protein supplements constitute the biggest component, and attention has been focused on the protein and energy levels of the feed. Meeting the bird's requirements for dietary protein contributes considerably to the feed costs (Skinner et al., 1992). The usefulness of a protein feedstuff for poultry depends upon its ability to supply a sufficient amount of the essential amino acids (EAA) that the bird requires, as well as the protein digestibility and the level of toxic substances associated with it (Scanes et al., 2004). The majority of an animal's dietary protein requirement is supplied by plant protein sources. Worldwide, traditionally, the most used energy and protein sources are respectively, maize and soybean. Cereals, like wheat and sorghum, and some plant protein meals are used all over the world as well. Soybean meal (SBM) is the preferred protein source used in poultry feed manufacturing. Its CP content is about 40–48%, and this depends on the quantity of hulls removed and the oil extraction process. Compared to the protein meal of other oilseed grains, soybean protein is favoured due to its well-balanced amino acid profile, especially the essential ones, enabling it to balance most cereal-based diets (Ravindran, 2013).

In general, vegetable (plant) protein sources are nutritionally unbalanced and poor in certain EAA and this decreases their biological value as they may not furnish the required limiting amino acids needed by birds for egg and meat production. Poultry nutritionists have paid more attention to the use of animal protein sources to create a balanced diets (Akhter et al., 2008). Organic cereals, or more specifically organic wheat, are the main components of poultry feed threonine (Labier and Leclercq 1994) with the lack of methionine having the greatest impact (personal communication Hi-Peak feeds) and are generally low in methionine, lysine and on the overall level of methionine in the diet. This lack has to be balanced by the inclusion of AA rich ingredients such assoya and other pulses. Greater use could be made of alternative cereals such as naked oats, which have been demonstrated to be nutritionally and economically viable as a wheat alternative within poultry rations (Maunsell et al. 2004), having higher levels of AA than wheat, and triticale that has better protein and lysine levels, 2.8% and 0.9% respectively, than wheat (Benbelkacem 2002). Soya is an important protein source, containing, as it does, a high proportion of easily digestible essential AA in a favorable pattern. Soya has to be toasted to reduce the high ANF content and the soya full bean has a very high fat content, which limits its possible use. Maize gluten complements soya bean meal in that it has a higher proportion of sulphur containing AA than soya bean meal but less lysine (Labier and Leclercq 1994). The home-grown organic protein sources that can be used to replace soya all have drawbacks so a combination of ingredients are needed. The grain legumes have varying levels of digestibility between and within species (Jeroch et al.,2000), the crude protein digestibility being between 74-88% with peas having the highest energy content (12.1 MJ/kg DM), a level that is in-line with the energy value of poultry feeds. However the use of legume proteins is limited by the ANF, such as tannins, lectins, protease inhibitors and pyrimids-glycosids, that are present in all of them to varying levels but most markedly in beans. Modern varieties have been bred with lower ANF but these are still high enough to limit their use. Over use of these proteins can lead to refusal of the feed (Holle et al., 2006). Some can be removed by treatments after harvest, such as peeling, autoclaving, expanding, extruding, toasting (Abel, 1996) or steam-pelleting (Vogt et al, 1979).). Animal proteins are well balanced in terms of EAA that are necessary for body growth and development, but they are expensive for commercial broiler production. Therefore, they are usually used to complement the amino acid balance in the diets rather than as the main protein source. Also the concern associated with disease transmission from products of animal origin is also taken into consideration. In general, the quality of animal protein sources is dependent on the composition of the raw material used. Animal protein supplements are derived from poultry and poultry processing; meat packing and rendering operations; fish and fish processing, and milk and dairy processing (Denton et al., 2005). Bone meal, meat meal, poultry meal, hydrolyzed feather meal and to a lesser extent blood meal have all been used as important feedstuffs for poultry feeding (Pearl, 2002). Fishmeal and fish oil either as a by-product of fish for human consumption or from sustainable fisheries can be used. It is an excellent source of protein and supplies high levels of lysine and methionine and contains useful minerals such as calcium and phosphorous. It's preferred use is in starter rations at a rate of around 2.5% where it helps to balance the AA requirements (Hancock et al.,2004). In various countries, during poultry feed manufacturing, care is taken that animal protein ingredients should be incorporated in the feeds, particularly for young birds, which require a high level of amino acids. The essential amino acid requirements are gradually decreased as the birds age, and it is possible to supply diets that contain lower animal protein content and relatively higher levels of plant protein to meet the demands of older birds (Ravindran, 2013).

Role of special protein products in poultry nutrition

1. Synthetic amino acids

The prohibition of the use of animal protein sources in poultry nutrition in many countries, and also the relatively high costs of these products demand new alternative products. The possible alternative in this situation is the use of plant protein. However, depending on the source, it is well known that there is a deficiency in one or more EAA in plant-based proteins. Achievement of an optimum balance of nutrients to meet the animal's requirement from a particular range of raw materials is a distinctive problem in feed formulation. As the ratio between the individual amino acids in protein concentrates varies significantly, there may be occasions when it is impossible, within the variety of raw materials available, to meet the animal's requirement for all amino acids. In these situations, supplementation with free synthetic amino acids would be very successful. In addition to this, dietary supplementation of synthetic amino acid to poultry diets increases feed conversion efficiency, lowers feed cost per unit of weight gain or production, reduces nitrogen excretion, and has other positive effects.

Instead of animal protein feeds in poultry nutrition, plant protein feeds are used with the supplementation of synthetic amino acids (Cmiljanić et al., 2005). Increasing the efficiency of protein and amino acid utilization is crucial for the reduction of feed costs and maximization of meat production with an absolute minimum intake of amino acids. Synthetic amino acids have been found to facilitate the formulation of diets with an ideal amino acid profile (Han and Lee, 2000).

Formulation with commercially available synthetic EAA to meet broiler requirements not only improves the overall amino acid balance, but allows for a reduction in CP, while also improving the general performance of broiler birds (Zarate et al., 2003). Investigations have demonstrated that poultry production can be considerably improved by the addition of synthetic amino acids along with probiotics and enzymes (Cmiljanić et al., 2003). Supplementation with limited amounts of synthetic amino acids (0.1–0.3%) to diets of swine and poultry could spare 2–3% of dietary protein and considerably reduce nutrient excretion, particularly nitrogen (Han and Lee, 2000).

2. Processed plant proteins

Plant proteins contain some anti-nutritional components that naturally exist within their structures, which can adversely affect the quality of the protein and limit its value in animal nutrition. ANFs are substances produced in natural feedstuffs as byproducts of the different metabolic processes of species (for example, inhibition or activation of nutrients, reduction in the digestive or metabolic utilization of feed) that detract from the nutritive value of the feed (Akande et al., 2010). The most commonly found antinutrients in plant protein sources are toxic amino acids, saponins, cyanogenic glycosides, tannins, phytic acid, gossypol, oxalates, goitrogens, lectins, protease inhibitors, chlorogenic acids, and amylase inhibitors (Akande et al., 2010). These can be divided into heat-labile and heat-stable factors. Among heat-labile factors are trypsin inhibitors, haemagglutinins, phytate, goitrogens and anti-vitamin factors. The heat-stable factors include saponins, oestrogens, flatulence factors, and lysinoalanine (Leiner, 1977). The most widely used plant protein source in animal nutrition is soybean. However, other cereal grains such as wheat, maize and sorghum as well as some plant protein meals such as canola, sunflower and peas are extensively used as well. In poultry, soybeans are used as SBM, which is made from the grinding of defatted flakes. New varieties of soybeans that have high protein and a lower oligosaccharide contents compared to conventional soybeans have lately been developed (Baker et al., 2011). In general, SBM is considered the best plant protein source due to its nutrient composition. Soybeans are excellent sources of protein and energy for poultry and swine. The high protein content, with its well-balanced and highly digestible amino acids, makes SBM a valuable protein for human and non-ruminant animal feeding (Kocher et al., 2002). However, as is a common feature of plant proteins, SBM has a high concentration of ANFs, which decrease its nutritive value (Marsman et al., 1997, Mehri et al., 2010). It has been concluded by van der Eijk (2015) that partial or complete replacement of SBM with SPC in the diets of young turkeys enhanced their 8-week body weight. In the same experiment they found that inclusion of SPI in lieu of SBM significantly improved feed utilization. It has been found that 5% replacement of soybean with processed soy protein (Hamlet Protein) in broiler starter diet resulted in an improvement in body weight and feed efficiency when the diet was fed for seven days. Similar improvements in body weight, mortality and feed conversion ratio of birds were found when the diet was fed for 10 days (van der Eijk, 2015). Philpotts and Norton (2003) suggested that there may be some possible benefits of feeding SPC or SPI during the first three weeks after hatching and that improperly processed soybeans should not be fed to young chicks. Some scientists have also reported a positive effect of Hamlet protein (HP) soy concentrate on feed intake.

3. Animal and blood by-products

An animal by-product can be simply defined as a part of a slaughtered animal which is not directly contributing to human nutrition (Hazarika, 1994). Protein supplements of animal origin are obtained from rendering operations, meat packing, poultry and poultry processing, milk and dairy processing, and fish and fish processing (Denton et al., 2005). Meat and bone offal, blood, bones, intestines, rumen content, and the carcasses of animals rejected by a meat inspector are considered the major categories of animal by-products used in animal nutrition. These by-products are characterized by their high content of good quality protein and energy, reasonable EAA profile and the absence of crude fibre and other ANFs in their composition (Konwar and Barman, 2005). Blood meal is used as a protein supplement, a lysine supplement, and vitamin stabilizer and as a source of trace minerals. Fresh blood has a high protein content of about 17% with a reasonable amino acid balance (Liu, 2002) and approximately 87% CP on a dry matter basis. Blood meal contains 9% total lysine with a minimum biological activity of 80% (Konwar and Barman, 2005). Blood meal can be included in poultry and swine diets up to a level of 25% (Hazarika, 1994). Previous reports have indicated that inclusion of 1–4% blood meal in diet can improve poultry performance (Anang et al., 2001, Nuarautelli et al., 1987), while others show no adverse effect of higher levels of dietary blood meal on chicken growth (Donkoh et al., 2002, Khawaja et al., 2007). However, Castelló et al. (2004) stated that supplementation of broiler chicken diet with more than 3% blood meal had a negative effect on feed intake and body weight gain of broilers.

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