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Review article

Specialized protein products in broiler chicken nutrition: A review

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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. It also requires knowledge about the protein sources available that can be used in poultry diets. 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. Minimization of the concentration of anti-nutritional factors (ANFs) and supplementation with immunologically active compounds are the main focus of gut health-promoting broiler diets. These diet characteristics are influenced by feed ingredient composition and feed processing. The general hypothesis is that these protein products are highly digestible and devoid of or contain less ANFs. 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.

1. 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. To cope with market demand for protein (meat), modern broilers are reaching market age sooner each year (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). However, protein is also one of the most expensive ingredients in poultry diets. Therefore, nutritionally and economically, proper protein usage is essential in all feeding systems, and wasteful usage increases the cost of production.

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The main objective of this review is to highlight the importance of some special protein ingredients, which are high-quality in nature and the potential of their inclusion in poultry diets.

2. 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). Vegetable (plant) and animal products are the two most important protein sources in poultry diets.

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). Because of their deficiency in some amino acids, plant proteins usually require a supplementary source of amino acids or other protein sources such as animal protein. Plant proteins are usually cheaper than animal proteins; however, there is a limitation to their use because of their content of anti-nutritional factors (ANFs). Most of these ANFs can be destroyed by thermal processing that causes an increase in the nutritional value sometimes and protein level of plant proteins (Adeyemo and Longe, 2007) due to the elimination of ANFs and freeing the protein in the plant protein products.

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). 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). Animal proteins are a beneficial component of poultry diets because they offer a high level of protein/amino acids, a high level of available phosphorus, reasonable amounts of other minerals, and moderate levels of energy.

Thus, it is necessary to include one or more of these animal protein sources in chicken diets. Hatchery by-products, feather and blood meals, and spent hens, have also been used for feeding non-ruminant animals (Moritz and Latshaw, 2001). To improve performance, there has also been some interest in substituting part of the SBM in poultry diets with animal products. Supplementation of animal protein sources may considerably improve performance parameters over standard diets. However, this may be because of the high concentration of EAA or it may be due to the lower percentage of indigestible carbohydrates present in SBM (Firman and Robbins, 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).

3. Role of special protein products in poultry nutrition

3.1. 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).

It is well known that one of the important roles of synthetic amino acids in animal nutrition is their ability to enhance the volume of readily available amino acids (nitrogen), as well as their promotion of lean meat production. Amino acids are also linked to the production of antibodies in animals (Han and Lee, 2000). Therefore, the development of immune function in poultry will be enhanced if they get an adequate amount of amino acids in their diets.

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). Researchers working on turkeys and broilers have indicated that the CP content can be significantly reduced in poultry diet with EAA supplementation, and the birds can achieve similar performance to that achieved on diets with high CP content.

3.2. Processed plant proteins

Plants provide the major portion of protein requirements by animals. However, due to their deficiency in one or more amino acids, plant proteins are usually fortified with synthetic amino acids or another protein source such as processed oilseed meal or animal protein concentrates. 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).

Numerous potentially valuable protein sources for animals will remain unexploited, if ways are not developed to overcome the antinutrient components in these sources. Several processing methods have been developed to expand the availability of a wide variety of feedstuffs and introduce them to the animal feed industry. The most common method used for plant and animal protein processing is thermal treatment (Papadopoulos, 1989). The heat-liable ANFs in the plant proteins can be decreased by heat treatment and this process increases the quality and protein level of plant proteins (Adeyemo and Longe, 2007).

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) and limit its inclusion in broiler chicken diets, especially at the starter phase. Based on the fact that old animals are more resistant to anti-nutritional constituents that negatively affect digestion than younger animals, only the good quality ingredients with low levels of antinutrients should be used in starter diets to achieve good health and higher growth rate (Dersjant-Li, 2002).

It has been recognized for many years that thermal processing of soybeans is needed to increase its nutritive value (Palacios et al., 2004) mainly by destroying the ANFs. After introducing the thermal treatment into the isolation process of soy protein products, numerous heat-sensitive substances are destroyed (Kim et al., 1978). Consumption of untreated soy protein may alter the intestinal morphology and physiology of broilers and cause a noticeable immune response (Peisker, 2001).

Various processed soybean products have been used in animal and poultry feeding. These include soybean protein concentrates (SPC), soybean protein isolates (SPI), and products in which the soybean was pretreated with enzymes and/or microorganisms. Processed soy products are distinctly different to SBM thus they have much lower ANFs activities, and contain a significantly lower amount of oligosaccharides and antigenic substances. Therefore, their nutritive value is much better than that of SBM and can be incorporated at high levels in animal diets (Peisker, 2001). Replacement of SBM with these processed products in animal diets is believed to result in a better growth performance because SBM may contain enough ANFs to exert their antinutritional effects (Saki et al., 2012). 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 (Philpotts and Norton, 2003). It has been demonstrated in experiments with pigs that both SPC and SPI have higher digestible protein and amino acids than SBM (Sohn et al., 1994). Lenehan et al. (2007) stated that both SPI and SPC have the same qualities (low ANFs) and their effects were better than SBM when they were used as milk protein substitutes offered to pigs aged from 21 to 35 days. In another study, when extruded SPC was partially substituted for SBM in a high-SBM diet (40%), there was a significant improvement in pig performance; however, this effect was absent when non-extruded SPC was used (Lenehan et al., 2007). Body weight of pigs was significantly increased due to the replacement of fishmeal with an HP product in pig diet. Feeding animals with processed soy or plant protein products that are purified or devoid of antinutritional compounds is important in order to optimize nutrient utilization and improve digestive physiology and subsequent productive performance of animals. Studies have shown that when SPC is used instead of SBM in diets for pigs, the negative impact of feeding SBM on the intestinal tract lining and on the serum antibody titer disappears (Peisker, 2001).

3.3. 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). Thus, they are used as valuable sources of protein in animal feeding. Of these animal by-products, animal nutritionists have shown a preference for the incorporation of blood and blood-derived products in feed.

Blood meal is a by-product of slaughterhouses and is used as a protein source in animal diets. Blood meal is considered one of the richest sources of lysine and a very good source of arginine, methionine, cystine, and leucine; however, it contains less glycine and very much less isoleucine than fishmeal or bone meal (NRC, 1994).

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). For many years dried blood products have been used in the feed industry, and these products have usually been regarded as quality protein sources in starter diets for pigs (Stein, 1996). Blood is prepared by collection after slaughtering and then heating it for protein coagulation. After this, excess water is discarded, and it is dried and powdered (Hazarika, 1994). The quality of the product obtained is greatly influenced by its purity and the method of drying. The temperature at which it is dried is important as overcooked meal is undesirable for animals and its use has a negative effect on the growth efficiency of poultry (Konwar and Barman, 2005). Porcine blood obtained by the modified spray-drying method can be treated as a potentially beneficial source of proteins, amino acids, microelements and some biologically active substances for non-ruminant animals (Jamroz et al., 2011).

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. A large proportion of blood is used for the production of plasma proteins and as a source of protein in pig and poultry diets. The introduction, approximately 10 years ago, of a more gentle drying process in the form of spray-drying has dramatically improved the responses obtained by feeding blood products to pigs. Application of various processing methods to the blood has resulted in the production of different blood-derived products, such as spray-dried plasma protein and spray-dried blood cells (Stein, 1996).

3.3.1. Spray-dried plasma

Spray-dried plasma is a typical source of protein source which is produced by the separation of whole blood into plasma and cell fractions (Stein, 1996). Spray-dried blood products are commonly derived from bovine or porcine origins and are highly digestible protein sources with good amino acid profiles (Castelló et al., 2004; Torrallardona, 2010). Since the late 1980s, spray-dried animal plasma products have been used in North America and Asia (Gatnau and Zimmerman, 1990) and their re-introduction into European animal diets is being considered for non-ruminant feeds (Castelló et al., 2004).

3.3.2. Production of spray-dried plasma

Fresh blood is collected at abattoirs and treated with an anticoagulant. The plasma and blood cell fractions are separated by centrifugation. The plasma is then heated and spray-dried, with the final product being a fine granulated powder (Cole and Sprent, 2001). The product may be further processed to standardize the immunoglobulin concentration. This step facilitates its handling at manufacturing plant, or makes it to be in the form of water-soluble product (Pettigrew, 2006). Although most of the available studies regarding plasma products in animal nutrition have been concentrated on the protein content of plasma, it is worth noting that plasma has some significant physiological effects inside the animal body. It is therefore collected and processed to preserve the functional properties of the proteins. Protein products such as spray-dried plasma (SDP), serum, or globulin concentrate are a combination of bioactive compounds such as biologically active peptides, albumin, immunoglobulins, fibrinogen, lipids, growth factors, enzymes, and other components that exert specific biological activities in the intestine in addition to their nutritional value (Campbell, 2011).

3.3.3. Role of spray-dried plasma in animal nutrition

Processed blood by-products, especially plasma, can be purified and used as high nutritional feedstuffs and a valuable source of proteins and other essential nutrients for animals. A sufficient drying process in the form of spray-drying has drastically improved the nutritional quality of blood by-products and improved the responses obtained by feeding it to animals. Spray-dried plasma products have been used in pig, fish, dog, cattle, and poultry nutrition (Castelló et al., 2004). Spray-dried porcine plasma and similar products have been used by the pig industry to support piglets prior to and after weaning(Coffey and Cromwell, 2001; De Lange et al., 2010; Van Dijk et al., 2001). Spray-dried plasmas of both porcine and bovine origins are usually used as sources of highly digestible and palatable proteins in pig production, and their feeding to weaning pigs in the starter phase enhances their performance over this stressful weaning time (Coffey and Cromwell, 2001; Van Dijk et al., 2001) through improved feed intake and feed efficiency (De Lange et al., 2010). Given the advantages of SDP for pig production, its potential benefits in the feeding of other production species have been established. Similar to pigs, improvements in feed intake, growth rate, and feed efficiency have been reported in calves (Quigley and Wolfe, 2003), broilers (Campbell, 2003), and turkeys (Campbell et al., 2004a) in response to the consumption of dietary spray-dried plasma. In diets of young birds, SDP incorporation has been found to improve the body weight and general growth performance (Jamroz et al., 2012).

The vast majority of researchers have reported that the response to dietary SDP was more pronounced in production conditions with high pathogen exposure than in clean rearing environments. This could be due to the immunological properties of SDP. Spray-dried plasma is processed to preserve the functional properties of proteins, including biologically active peptides such as albumin and IgG (Quigley and Wolfe, 2003). Dietary spray-dried porcine plasma could possibly improve the performance of broilers raised under challenge conditions, predominantly in the starter phase (Henn et al., 2013). Same observations have been reported in turkey poults (Campbell et al., 2004a) and pigs (Coffey and Cromwell, 1995; Stahly et al., 1994). Spray-dried plasma contains a diversity of functional proteins such as albumin, immunoglobulins, growth factors, and biologically active peptides (Borg et al., 2002). These proteins are more efficient during animal exposure to environmental or immunological challenges. Coffey and Cromwell (1995) stated that pigs housed in a challenging environment grew more efficiently in response to SDP consumption than pigs reared in a sanitary environment. Similar responses to spray-dried serum have also been observed in broilers housed in different environments (Campbell et al., 2003). An improvement in the health and growth efficiency has been observed in animals fed on diets containing SDP and challenged with *Escherichia coli* (Bosi et al., 2001; Quigley and Drew, 2000) and *Cryptosporidium* (Hunt et al., 2002).

The precise mechanisms behind the improved growth and health of broilers fed plasma remain unclear. However, some researchers have linked this improvement to the nutritive properties of plasma proteins. Blood products such as spray-dried whole blood, plasma or red cells have been documented as protein sources with high nutritional value due to their excellent amino acid profile and digestibility, and have been used as ingredients in farm animal diets for many years (Castelló et al., 2004). Therefore, from a nutritive perspective, the improvement in the growth performance of birds fed SDPP may be due to the product being a high quality protein with a good amino acid profile that can support gut development and rapid muscle growth. The mechanisms by which the product functions may be multifaceted. In pigs, palatability of spray-dried plasma, which increases feed intake, has been suggested as a mechanism for improved performance (Ermer et al., 1994). However, findings from recent studies have reinforced the idea that the benefits of spray-dried plasma are derived from its immunological properties (Hansen et al., 1993; Zhao et al., 2008). The presence of immunologically active compounds in blood products such as immunoglobulins, specific blood proteins, and nucleotides have positive effects on weaned pigs and chickens receiving diets containing porcine blood by-products (Bregendahl et al., 2005; Owusu-Asiedu et al., 2002).

Although the antibacterial action of spray-dried plasma has not yet been confirmed, the literature has highlighted both the external benefits on the microbial community of the intestine as well as the internal effects on pigs (Edwards et al., 2010). These effects could also be implemented in birds. The effects are mainly localized in the gut; however, some systemic effects have also been identified. The proposed theory is that immunoglobulins and glycoproteins exist in plasma products and have the potential to bind with pathogenic bacteria receptors and thus reduce their adhesion to the mucosal wall in the gastrointestinal tract (GIT) (Bosi et al., 2004; Garriga et al., 2005; Nofrarias et al., 2006; Pierce et al., 2005). Furthermore, antibodies that exist in spray-dried porcine plasma also have the ability to inhibit or reduce pathogenic colonization in the GIT (Owusu-Asiedu et al., 2002). These theories could explain the greater efficiency of plasma in high-pathogen environments than in clean environments (Coffey and Cromwell, 1995).

Inclusion rates of spray-dried plasma products in research trials with pigs have ranged from 2 to 25% (Torrallardona, 2010). However, in poultry nutrition the inclusion rate has ranged from 0.25 to 4%. Dose-dependent studies have been conducted to determine the optimal inclusion rate of spray-dried porcine plasma (Coffey and Cromwell, 1995; Kats et al., 1994). The optimal inclusion level in pigs has been reported to range between 4 and 8% (Torrallardona, 2010; Van Dijk et al., 2001). More studies are required to determine the optimal level of spray-dried plasma in the diets for the various growth stages of broiler chickens.

The effects of dietary blood by-products, more specifically spray-dried porcine plasma, on the intestinal integrity of animals have been observed. However, the effects are not always consistent. Longer intestinal villi have been observed after inclusion of spray-dried porcine plasma in broiler diets (Jamroz et al., 2011, 2012). Performance improvement (Nofrarias et al., 2006; Pierce et al., 2005), insulin-like growth factor stimulation, and development of the small intestine (De Rodas et al., 1995; Jiang et al., 2000) have also been confirmed in pigs and pheasants. The tendency of spray-dried plasma to improve the absorptive capacity by increasing villus height and the villus height/crypt depth ratio has also been reported (King et al., 2008; Torrallardona et al., 2003; Zhao et al., 2007). In contrast, various studies carried out on pigs, have indicated that feeding dried plasma to the animals as a source of protein has little or no effect on the morphological aspects of the intestinal wall (Nofrarias et al., 2006) or on villus height, crypt depth, and villus and crypt goblet cell density (King et al., 2008). Furthermore, Jiang et al. (2000) found no influence of spray-dried plasma on villus or crypt morphology or the cell proliferation index.

In searching for the sources of bioactive substances which can naturally stimulate immunity and improve the general health status of animals, nutritional experts have focused their interest on the use of blood by-products as raw materials in animal nutrition (Coffey and Cromwell, 1995; Orda et al., 1988). The positive influences of dried blood plasma on immunological reactions and intestinal wall functions of weaned pigs and other non-ruminant animals have been reported (Campbell et al., 2009; De Rodas et al., 1995; Godfredson-Kisic and Johnson, 1997; Nofrarias et al., 2006). The activity of blood by-products has been associated with specific immunoreactive globulins and nucleotides that exist in the composition of blood products (Moretó and Pérez-Bosque, 2009; Rodriguez et al., 2007; Shahidi et al., 1984). An improvement in the growth performance and general health status of animals (pigs, poultry, calves, and pets) has been observed due to spray-dried plasma feeding (Campbell et al., 2003, 2004a,b; Coffey and Cromwell, 2001; Quigley and Drew, 2000). Mobilization of the mucosa membrane and the expression of the activation of immunological areas have been observed after inclusion of spray-dried porcine plasma in broiler diets (Jamroz et al., 2011, 2012). Modulation of the immune system, antibody functions, inflammatory response, and modification in the intestinal morphology as responses to dietary SDP have also been confirmed in numerous studies carried out on young pigs (Cain et al., 1992; Campbell et al., 2009; Coffey and Cromwell, 1995; Kats et al., 1994; Owusu-Asiedu et al., 2002; Rodriguez et al., 2007).

4. Conclusion

From the literature, it is evident that protein has demonstrated effects beyond its roles of building blocks of the body tissues: from a better gut functioning to an enhanced immune system. Adequate dietary provision of protein and amino acids is necessary for sustaining normal immunocompetence and protecting the host from a variety of diseases in all species.

As a commercial process when dealing with poultry nutrition, the first attention is given to the cost of the ingredients used. Therefore our understanding of the role that nutrition can play in the development of birds has probably been restricted by our reliance on the use of the most available and cheapest traditional feedstuffs. However, the quality of the feedstuffs has an important role in maintaining chicken production and profitability. Numerous potentially valuable protein sources for animal nutrition will be exploited if they are properly processed. Given the substantial improvements made in the understanding of intestinal nutrient assimilation, a complimentary objective in nutrition might be to formulate diets for birds with consideration for the optimization of growth, function and health of the gut as a priority. The present review highlights the benefits of using high quality protein products such as spray-dried porcine plasma and processed soy proteins in poultry feeding. These two products and similar products are often considered as interchangeable in poultry diets, which may be true from a nutritional perspective. As these products have high nutritional value and are devoid of ANFs which may impair the intestinal development and have adverse effect on the productivity of bird. Therefore its feeding could have positive effect on birds' performance and subsequent physiological function.

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