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Feed additives in poultry nutrition

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Abstract

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The use of feed additives to improve the efficiency of growth and/or eggs production, prevent disease and improve feed utilization is a strategy to improve the efficiency of the poultry industry. Feed additives may not enter the market in Europe unless authorisation has been given following a scientific evaluation. The use and development of enzymes, phytogenics, prebiotics and probiotics has gained momentum in poultry feeding. The enzymes widely used by the industry are the non-starch polysaccharidases that cleave the non-starch polysaccharides in viscous cereals, microbial phytases that target the phytate-complexes in plant ingredients. Proteases are of interest to improve protein and amino acid digestibility, particularly in very young animals. Phytogenics are an alternative to in-feed antibiotics to prevent the risk of developing pathogens and also to satisfy consumer demand for a food chain free of drugs. Probiotic feed additives generally consist of one single strain or a combination of several strains of bacteria, Bacillus spores or yeasts species. Prebiotics are non-digestible food ingredients, such as fructo-oligo-saccharides, xylo-oligo-saccharides, mannan-oligo-saccharides and galacto-oligo- saccharides that are also used in feeds to protect poultry against pathogens. Future research needs to be directed towards understanding how combinations of these additives can be used to improve the efficiency of poultry production.

Keywords: enzymes; phytogenics; probiotics; prebiotics; poultry

Introduction

There are many challenges nowadays in poultry production, including food safety, environmental issues, standardizing welfare standards, ban of nutritive antibiotics, gut health, feeding rich in fiber ingredients and maintaining high efficiency of production. The cost of the feed accounts for approximately 70% of the cost in poultry production (Cooke, 1987), thus seems to be the most significant challenge for the poultry industry. If farmers are to be capable of feeding the estimated 9 billion people in the world by 2050 then they must find a way to produce relatively inexpensive high quality products, with lower environmental impact when feeding raw materials that do not compete with humans.

The use of feed additives able to improve the efficiency of growth and/or eggs production, prevent disease and improve feed utilization is an option to tackle the aforementioned challenges. The European Feed Standard Agency (EFSA) describes feed additives as products used in animal nutrition for purposes of improving the quality of feed and the quality of food from animal origin, or to improve the animals' performance and health, e.g. providing enhanced digestibility of the feed materials. Feed additives may not be put on the market unless authorization has been given following a scientific evaluation demonstrating that the additive has no harmful effects, on human and animal health and on the environment. EFSA recognizes five categories of feed additives including zootechnical (enzymes, probiotics, prebiotics, certain phytogenics), nutritional (vitamins and amino acids), technological (organic acids, antioxidants, pellet binders etc.), sensory additives (flavors) and coccidiostats. However, the use and development of enzymes, phytogenics and probiotics has gained momentum in poultry nutrition.

Exogenous enzymes

The zootechnical feed additives are a group of products that affect favorably the performance of animals in good health through improved digestibility or stabilized gut flora, or affect favorably the environment. Exogenous enzymes are within the most used feed additives. Enzymes are proteins that facilitate specific chemical reactions and work on specific substrates. The enzymes widely used by the industry are the non-starch polysaccharidases (NSPases) that cleave the non-starch polysaccharides (NSP) in viscous cereals (wheat, barley and triticale) and microbial phytases that target the phytate-complexes in plant ingredients (Ravindran & Son, 2011; Pirgozliev & Bedford, 2013). The majority of NSPs in wheat and rye are arabinoxylans (pentosans), whilst mixed-linked beta-D-glucans are the most nutritionally significant in barley. The physicochemical properties of the soluble, higher molecular weight NSP result in increased digesta viscosity which is correlated with reduced bird performance (Bedford, 2006; Pirgozliev et al., 2006). In particular, soluble viscous NSPs depress the digestibility of protein, starch and fat in broiler diets, an effect which is easily overcome through use of the appropriate enzyme (Bedford, 2006; Whiting et al., 2017). There is no vertebrate animal that produces enzymes capable of hydrolysing the NSP in diets. Dietary NSPases can break the bonds between sugar units of NSP and significantly reduce the gut content viscosity. Lower gut viscosity will lead to a more complete digestion and absorption of nutrients, reduced microbial proliferation and improved gut health (Pirgozliev et al., 2010; 2015a; Abdulla et al., 2017). The NSP degrading enzymes can also produce some oligosaccharides that may act as prebiotics in the gut of poultry (Masey O'Neill et al., 2014). Dietary NSPases can also improve the hepatic antioxidant capacity of broilers (Pirgozliev et al., 2015b).

Approximately 600 to 700 g/kg of the plant-P is present as phytate. Phytic acid (myo-inositol hexakis-dihydrogen-phosphate, IP6) is a polyanionic molecule with 6 phosphate groups and is capable of forming insoluble complexes with divalent cations, starch and protein, reducing their availability for poultry (Selle & Ravindran, 2007). Poultry can produce some endogenous phytase but this is insufficient for the effective hydrolysis of dietary phytates. The detrimental effects of phytates in the diets of poultry can be ameliorated by the addition of microbial phytases. Phytases (myo-inositol hexaphosphate phosphohydrolases) are enzymes that can hydrolyse the ester bonds between the phosphate groups and the inositol ring in phytates, increasing the dietary available P (Selle & Ravindran, 2007). The benefits of using dietary phytases are not restricted to the improvement of mineral retention but may improve performance and energy and amino acid availability (Selle & Ravindran, 2007; Pirgozliev et al., 2011). Research by Karadas et al. (2010) also found that dietary phytase can improve the hepatic antioxidant capacity of broilers.

In animal feed, protease supplementation is of interest to improve protein and amino acid digestibility, particularly in very young animals where the relative activity of endogenous proteases may not be optimal (Walk et al., 2018). In addition, protease supplementation may improve ingredient quality by reducing ingredient variability and mitigating negative effects of heat-stable trypsin-inhibitors or lectins (Cowieson et al., 2016). Exogenous protease supplementation is gaining in popularity in animal nutrition with beneficial effects on growth performance, nutrient digestibility and endogenous enzyme secretion. In addition, report by Olukosi et al. (2015) found that whereas protease by itself improved nutrient utilization and increased solubilization of NSP components, at the lower dose, a combination of xylanase, amylase, and protease produced effects greater than those of protease alone.

Tannase enzyme was recently supplemented to broiler feed in order to improve feeding value of diets containing field beans (Abdulla et al., 2016 a, b). Although results were promising, further research is warranted to study the effectiveness of tannase supplementation in poultry diet formulations by dose response trials with purified tannase preparations.

Phytogenics

Phytogenics, also referred to as plant secondary metabolites, phytochemicals, phytobiotics or botanicals, are plant-derived products/extracts and include a wide range of substances such as herbs, spices, essential oils and oleoresins, reported to exhibit growth promoting and/or therapeutic properties (Windisch et al., 2008; Bravo et al., 2014; Pirgozliev et al., 2015 c). Initially, phytogenics have been extensively studied because of the adverse effects that they have when ingested by animals (Acamovic & Brooker, 2005). However, the use of phytogenics as an alternative to in-feed antibiotics to prevent the risk of developing pathogens resistant to antibiotics and also to satisfy consumer demand for a food chain free of drugs, in poultry production has gained recent interest (Dibner & Richards, 2005). The ability of phytogenics to contribute to the health of the host is well documented (Windisch et al., 2008); however, the exact mechanisms by which PE exerts its effects remain speculative (Pirgozliev et al., 2015d; Karadas et al., 2014). It should be noted, that phytogenics represent a diverse group of natural products, some of which may be nutritionally valuable but many of which have no nutritional value or even antinutritional properties. Although precise numbers are at best an estimate, of the over 100 000 different compounds of natural origin that have been described, approximately 80 000 are derived from plants (Acamovic & Brooker, 2005). Plant extracts also widely vary in their chemical structures. Since the effects of phytogenics depend to a great extent on the chemistry of the compounds, it is impossible to have a uniform explanation on their mode of action.

Probiotics and prebiotics

Probiotics are live microorganisms which are supplemented to the feed in order to establish a beneficial gut microflora (Fuller, 1992). A probiotic is defined as a live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance. In general, the introduction of the concept is attributed to the Nobel laureate Élie Metchnikoff. Probiotics are mainly active in the small intestine. Probiotic feed additives generally consist of one single strain or a combination of several strains of bacteria, *Bacillus* spores or yeasts species (multistrain). Preparations authorised for use in animal nutrition in the European Union include different strains of *Enterococcus, Bacillus, Lactobacillus, Pediococcus* or *Saccharomyces*. The mode of action of probiotic feed additives is mainly based on three principles including competitive exclusion, bacterial antagonism, and immune modulation (Patterson & Burkholder, 2003).

Prebiotics are non-digestible food ingredients (readily fermentable sugars), that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon (large intestine), and thus improve host health (Patterson & Burkholder, 2003). Most potential prebiotics are carbohydrates (such as oligosaccharides). Some prebiotics that are used in this manner against pathogens are fructo-oligo-saccharides (FOS), xylo-oligo-saccharides (XOS), mannan-oligo-saccharides (MOS) and galacto-oligo- saccharides (GOS).

Conclusion

Each of these feed additives has their specific benefits. Future research needs to not only identify new/or improved possibilities for poultry feeds, but also research is needed to understand how combinations of these additives can be used to improve the efficiency of poultry production.

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