Do enzymes have a role to play in gut health?

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Following World War II, there has been a substantial increase in the global population. This growth has increased demand for food which has been reflected in a performance driven growth in animal production. Average daily gain and feed efficiency have been key criteria of production success for several decades. The animal production industry has also been very successful in meeting these criteria.

Average daily gain in broilers has risen from around 10-20g/day in the 1960s to almost 50g/day in 2011.

At the same time Feed Conversion Ratio, (the amount of feed required to achieve 1kg growth) has substantially reduced. However, this focus and surge in animal production has led to some issues, which have become challenges at the beginning of the 21st Century.

Nutritional solutions

Many important factors such as increased incidence of disease, compromised animal welfare, public health issues, antibiotic resistance, demand for better quality animal products, public defiance to animal farms in the vicinity of humans due to odour etc, have increased pressure on animal production systems, forcing the need to find solutions. Many of these factors are related to the gastrointestinal microbiota and gastrointestinal health, which has triggered an imperative worldwide to find nutritional solutions which will help solve these issues without reducing the level of productive performance.

Until recently, use of antimicrobial growth promoters (AMGPs) has helped immensely during this growth phase of the animal protein industry. However, due to increasing concerns about antibiotic resistance and demands from both society and legislation, more and more countries are banning use of AMGPs in livestock nutrition. The absence of these AMGPs will lead to challenges around resolving gut health related issues so that the performance of animals is not compromised.

Enzymes were first used in the poultry industry in the 1980s and are now widely used to make more nutrients available from the feed, which improves bird performance and provides feed cost savings. However, more and more data/evidence is emerging that enzymes impact gut metabolism and balance, which aids in maintaining gut health, a feature that may become more important in the post AMGP era.

Enzyme combinations

Enzymes are categorised according to the substrates that they target and in order to deal with the complexity of substrates in modern broiler diets multiple enzyme activities are frequently needed.

One such combination enzyme is a mixture of xylanase, amylase and protease activities. Exogenous xylanase targets the soluble and insoluble arabinoxylans in cell walls. These arabinoxylans can trap nutrients in the cell walls and the soluble fractions can also induce viscosity in the gut which results in reduced digestion of nutrients and a reduced passage rate of feed through the gut.

Use of exogenous xylanase has two well researched benefits, firstly releasing encapsulated nutrients such as starch and protein from the cells and secondly reducing the viscosity of the digesta, both leading to improvements in digestibility.

The breakdown of non-starch polysaccharides by xylanase can also have a beneficial effect on the gut microflora by creating conditions that encourage beneficial bacteria through reduction in viscosity and production of small oligomers that can be used by the beneficial bacteria in the lower gut.

Exogenous amylase is used to increase the hydrolysis of starch and improve starch digestibility which results in more energy being released for the bird.

Exogenous proteases are used to increase the hydrolysis of proteins in the feed, including hydrolysis of proteinaceous anti-nutrients such as trypsin inhibitors and lectins, resulting in improved digestibility of protein and amino acids.

Research on enzyme combinations containing xylanase, amylase and protease (XAP) has demonstrated improvements in the nutritive value of the diet.

Several studies have demonstrated incremental improvements in energy digestibility when dietary carbohydrases (xylanase and amylase; XA) were used with or without protease. Romero et al (2013) analysed four digestibility studies that had compared the effects of XA or XAP in maize based diets with or without distillers dried grains with solubles (DDGs).

A meta-analysis of the four studies showed that XA increased ileal digestible energy and AMEn by 77 and 67 kcal/kg respectively, whereas XAP increased them by 98 and 93 kcal/kg feed respectively. In addition the XAP was shown to increase protein and amino acid digestibility This increase in digestibility was between 12-13% of the ileal undigested amino acid fraction, irrespective of the amino acid concerned.

Romero and Ravindran (2011) also demonstrated significant improvements in crude protein as well as fat and starch digestibility with the XAP combination. The improvements in digestibility seen in trial work can be used when formulating commercial diets with the product and can allow producers to reduce the amount of added fat in their diets or to add cheaper raw materials with a lower nutritional value to the diet, without compromising animal performance.

A lifecycle assessment has demonstrated that use of XAP in this way has benefits for the environment by reducing the greenhouse gas emissions from poultry production by 5%. The increases in digestibility seen with the XAP combination translate into improved growth and feed efficiency of the animal. Over eight trials the

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XAP combination was able to reduce the amount of feed required per kg broiler meat by between 3.8 and 8.7%, depending on the feed formulation.

Impact on the gut

Maintaining a stable gut environment and averting the subsequent increase in use of therapeutic antibiotics in animal production is the biggest challenge for farming.

Exogenous enzymes (phytase, protease, amylase, xylanase, beta glucanase etc) are known for their efficacy in degradation of anti-nutritional factors and improving digestibility of nutrients. However, recent scientific studies shed light on their ability in maintaining a stable gut environment by favouring host and normal microflora and creating specific conditions detrimental to the growth of non-beneficial bacteria.

The mechanism of action of enzymes differ in the upper and lower gastrointestinal tract. In the upper gastro-intestinal tract, exogenous enzymes increase the digestibility of nutrients, leading to a reduction in the availability of indigestible substrate for microbial growth.

Furthermore, viscosity of the chyme is also reduced when feeding viscous grains such as wheat or barley, increasing the passage rate of digesta. These conditions lead to a reduced microbial population in upper gastro-intestinal tract, consequently reducing the threat of proliferation of non-beneficial bacteria.

While degrading viscous β-glucans and arabinoxylans from wheat and barley, small oligomers and free sugars are produced and some of these are poorly absorbed in the upper intestinal tract. These oligomers and sugars are utilised by certain beneficial bacteria in the hind gut leading to increased VFA production and containment of proliferation of non-beneficial bacteria that favour higher pH.

Choct et al (1999) reported an interesting shift of VFA production from ileum to caecum. In this study, VFA production was lower in the enzyme treated group in the ileum, while in contrast in the caecum VFA production of the enzyme treated group was higher than the control.

These results underline the earlier mentioned degradation of fibre fractions into smaller oligomers and sugars that are fermented further down the tract in caecum. This shift can benefit microbial balance in the lower GIT and thus aid in maintaining intestinal health. These effects were evident in several published studies, showing higher performance of the animals along with reduction of non-beneficial bacteria in the gastro-intestinal tract.

Amerah et al (2012) showed a significant reduction in salmonella prevalence in the caeca of broilers when xylanase was added to the diet. Some studies reported positive effects of xylanase inclusion on gut barrier function when birds were challenged by C. perfringens. These positive effects of enzymes, in particular carbohydrases, on gut environment, have been shown to help boost effects of other feed additives such as probiotics.

Conclusion

Enzymes are known for their effects on the anti-nutritional factors and liberating more nutrients from the feed, allowing the use of lower cost ingredients to save feed cost, without losing performance of the birds.

However, their impact on the gut environment, and consequently on gut health is receiving growing attention.

At times when there is immense pressure on broiler producers to reduce antibiotic usage without losing performance and profitability then understanding the role of feed enzymes in gut health becomes particularly important.

The ability of enzymes to both liberate nutrients and stabilise gut environment results in better animal performance and reduces feed cost and supports their use as an important and essential feed additive in the post-AMGP era. ■

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