New enzyme concepts for broiler nutrition

Enzymes are strategic additives in broiler nutrition today. Besides phytase to increase plant phosphorus digestibility, fibre degrading enzymes are most important. Protease concepts are developing for specific objectives like N reduction.
However, new enzyme applications (concepts) based on fibre degrading enzymes are being developed and validated in vivo.

In poultry diets, plant based raw materials containing non-starch polysaccharides (NSP) are the most important feed ingredients. Specifically grains are important energy and protein sources and can comprise up to 60% of broiler diets. They typically represent about 50% of the protein as well as about 50% of the NSP-fibres of the total diet. Complete oil seeds are important energy sources, but their incorporation in the total diet is limited by the oil content. By-products from grain and oil seeds are major protein sources. Their incorporation levels in the diet are relatively low and dependent on the quantity and composition of their NSP-fibres. They roughly represent the other 50% of total protein and fibre in the final feeds.

Fibres influence several aspects of broiler nutrition due to the fact that they exist in soluble and insoluble form (physicochemical characteristics of gut content), are partly fermentable and non-fermentable (microbiome and metabolome characteristics of the gut content) and influence water holding capacity and transit time.

NSP analysis of common raw materials give a clear indication of the important types of NSP fibres. The “NSP-sugar-fingerprint” obtained after extraction and acid hydrolysis of fibres will deliver sugar monomers giving an indication of the main fibre composition. Based on physicochemical isolation techniques and in depth structural carbohydrate research, the polymeric composition and characteristics of the different fibres can further be elucidated.
Xylans and glucans are important in grains like corn, wheat and their by-products. Glucans are more prevalent in the outer parts like the aleuron and pericarp layer of wheat (Steenfeldt et al., 1995). In by-products of oilseeds like soybean meal, additional to glucan and xylan, the levels of pectin, xyloglucan and cellulose type of fibres are quantitatively or structurally important (Caffall and Mohnen, 2009). The xyloglucans are important fibres and majorly interlinked with cellulose. The quantity of hulls in the final extracted by-product meals will influence the final fibre composition.

The physicochemical characteristics of fibres will be determined by their composition, the quantity and the type of linkages. The solubility of the NSP-fibres differs strongly depending on the feed raw material and the specific tissues of the grain from which they originate.
Corn has a similar NSP-fibre composition and quantity as wheat, but there is a major difference in the solubility of fibres in corn. They are more insoluble due to a higher degree of substitution and esterification (Appeldoorn et al., 2010). The ratio arabinose/xylose ratio (A/X) of arabinoxylans gives an indication of their degree of substitution. A higher substitution indicates a lower solubility.

Wheat and corn by-products contain more insoluble fibres as during processing, the outer layer of the grain are concentrated in the by-product raw materials. Glucans in outer layers of the grain will represent more cellulose-insoluble-types of fibre.

Soybean meal and rapeseed meal, as an example, additionally contain high levels of pectin type of NSP-fibres, which are soluble for an important part (Knudsen, 1997). Other types of by-products like sunflower meal and DDGS can contain important levels of insoluble glucans like cellulose.
Pectins are a major component of primary and secondary cell walls (Gorshkova et al., 2009).
Pectin is composed of monomeric sugars like galactose, arabinose, galacturonic acids and rhamnose. Some major pectin polymers consist of poly-galacturonic acid, arabinan, xylogalacturonan, arabinogalactan and rhamnogalacturonan I and II.

Poultry is unable to digest NSP-fibres in the small intestine. Soluble fibres are involved in viscosity development in the small intestine, which is indicated as anti-nutritional for broiler nutrition. They limit efficient absorption of nutrients and feedback mechanisms of nutrient monomers and can lead to the loss of endogenous enzymes due to oversecretion. Insoluble fibres on the other hand limit the access of endogenous enzymes to the nutritional substrate and carry away nutrients from the small intestine into the large intestine and caecum. On the other hand, soluble NSP-fibres also have positive effects on villi development. They are fermented to volatile fatty acids of which some are used by enterocytes and they increase the overall nutritional value of the raw material i.e. energy value (Dierick and Decuypere, 1994). The fermentation of soluble fibres in the large intestine and caecum is dependent on the raw material type e.g. fibres from soybean meal are more fermentable then those from rapeseed meal (Pustjens et al., 2014).

Insoluble fibres influence the gut motility and are mentioned as platforms for gut microbiome association. In general, both soluble and insoluble fibres have an important impact on the gut microbiome and metabolome (Caprita et al., 2010). The influence of soluble fibres on the microbiome is also stated as prebiotic (Zhang et al., 2014). The gut microbiome presents a first barrier for pathogenic microorganisms and it interacts with the gut associated lymphoid tissue and local immune system. This means that fibres have an important impact on the gut microbiome equilibrium and GALT system interacting with it and indirectly on the nutrients which are used to maintain this system.

An increasing proportion of soluble pectin to insoluble cellulose has a negative effect on gut morphology and performance of broilers (Saki et al., 2011).
On the other hand, insoluble fibres can positively influence young broiler performance. It was shown that the addition of insoluble cellulose has a positive impact on performances in the starter period due to increase of specific bacterial species in the caecum (Maesschalck, 2015).

Nutritionally important is the fact that NSP-fibres are connected with dietary proteins through direct linkage or inclusion. They can limit the availability of protein for hydrolysis in the stomach and the small intestine and

hinder an efficient absorption of amino-acids in the small intestine which are needed for optimal animal production.
On the other hand, high levels of excess protein in the large intestine lead to energy loss by the animal due to the need to detoxify amino-acid degradation products resulting from microbial fermentation.
Also in general in broiler nutrition, excess protein is avoided to limit the water intake and to keep under control wet litter (Marks and Pesti, 1984).

Furthermore, due to environmental reasons N-reformulation is an important issue in certain geographical areas of intensive animal production.
Also today, with the high cost for protein, reduction of total N and digestible amino-acids in diets can realise important economic advantages in feed formulation.
Whereas NSPase enzymes are commonly used to avoid negative effects of soluble fibres, impact of enzymes on insoluble NSP fibres need more attention in broiler nutrition and open new horizons for optimal feed formulation.

Many and different enzyme types are on the market and used routinely today. Possibilities to optimize broiler nutrition and performance are dependent on the type of enzyme activities, their level in the enzyme product (concept) and the dosage of this concept into the diet. To obtain sufficient NSP hydrolysis of soluble and insoluble fibres, the addition of minimum threshold levels of well-chosen enzyme activities are needed.

Fibres have various sensitivity to enzyme action. Due to a lower degree of substitution for instance, beta-glucans are more easily hydrolysed by added glucanases than most xylans.
Insoluble fibres like cellulose, on the other hand will require higher threshold quantity and a broad composition of enzyme activities to obtain partial hydrolysis. A cooperative action between different enzyme activities targeting different fibres in the insoluble fibre network is needed. A specificity of the broiler digestive tract is the short transit time. Added enzymes have to perform their actions in time at the right gut location within the restricted time frame available. Enzyme combination and concentration are important in this context.

It is clear that the multiple effects of fibres and interactions of the different related phenomena mentioned in the digestive system of broilers are sometimes seemingly contradictory and complex and difficult to predict concerning possible practical use. Only animal trials and performance measurements using well designed feed compositions and well characterised enzyme concepts can indicate if the overall effects are economically interesting for broiler production.
AVEVE Biochem NV has 30 years of experience in designing enzyme concepts, based on more than 250 animal trial set-ups.

We demonstrated recently that by using new NSPase enzyme concepts and adapted NSPase dosage (quantity) to broiler feeds, performance increase and formulation advantage can be realised when the needed threshold level of enzyme activities are supplemented.

A totally new concept is "high dosing" of NSPase.

We demonstrated for the first time that "double dosing" of NSPase enzymes can be used to reformulate broiler diets to lower total protein and to lower minimum digestible amino-acid levels, indicating increased protein digestion (De Keyser et al., 2016).

It proves that high dosing NSP enzymes open the fibre structure and improve access of animal proteases to the dietary protein present, which results in increased protein digestibility. "High dosing" of NSPase enzyme containing endo-1,4-beta-xylanse and endo-1,3(4)-beta-glucanase to a more economic broiler diet re-formulated with -3% reduced total protein and -3% reduced minimum digestible amino-acids, restores normal growth and FCR comparable to the positive control feed. High dosing of NSPase can realise equivalent protein reformulation as a mono-component protease in the same N-reformulated diet. High dosing of NSPase indicated however to be more economic than the use of protease for this reformulation purpose.

Another new concept is the use pectinase enzyme activity.

We demonstrated that the addition of high pectinase activity on top of endo-1,4-beta-xylanase and endo-1,3(4)-beta-glucanase, increased growth rate and significantly decreased FCR on top of a standard broiler wheat-soybean meal and corn-wheat-soybean meal diet. As soybean meal is the major source of pectins in these diets, we presume that the performance increase is mostly related to the action of pectinase on soluble and insoluble soybean meal pectins.

Soybean meal products are standard in broiler diets and the performance effect seems not dependent on the grain type in the diets.

Based on many animal trials with a broad range of NSPase enzyme activities, high levels of pectinase on top of xylanase and glucanase seem to hold an important potential to further improvement of broiler performances based on the additional enzyme actions on the major fibres present in the protein source raw materials of the broiler diets.

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