Relevance of carbohydrase enzymes in pig diets and variability in nutrient content in common feed ingredients.

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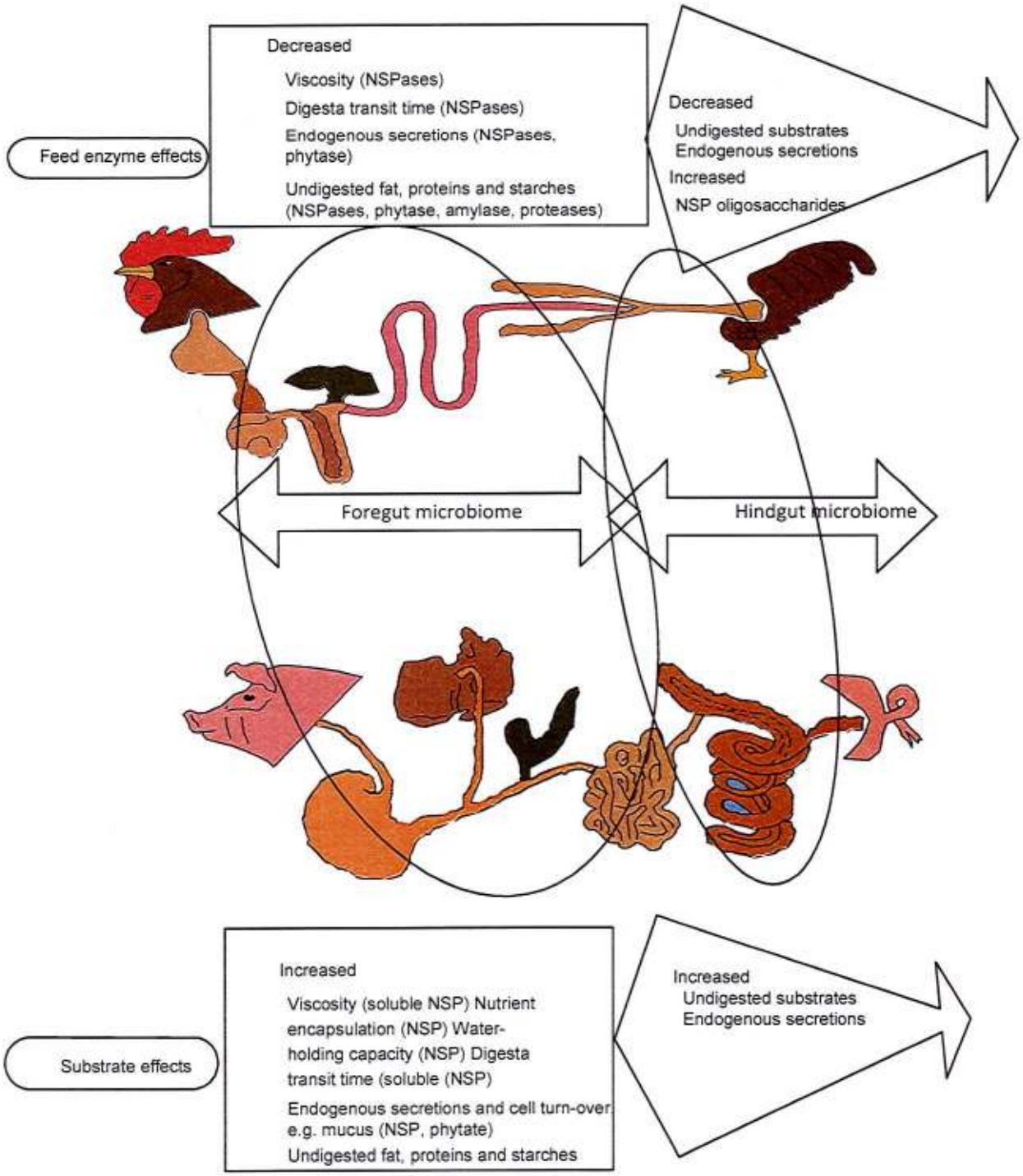
With the recent price volatility of conventional feed ingredients, the animal feed industry will continue to seek for alternative cost-effective feed ingredients such as cereal by-products. However, the successful applications of alternative ingredients will be dependent on the characterisation of their nutritive value, availability of technologies for mitigating risk associated with them and potential economic benefits when formulated correctly into pig diets. For example, the high non-starch polysaccharides (NSP) and indigestible protein contents in cereal by-products can limit their inclusion into pig feed, however, supplementation with NSP-degrading enzymes and proteases might allow high inclusion of such feed stuffs. The ability to find and evolve the next generation of feed enzymes will be driven by understanding the target substrates and the implications to animal nutrition.

Enzymes are biological catalysts that speed up reactants and act on specific substrate or reactants. Generally the enzyme systems available for the animal feed industry are derived from microbes (fungi and bacteria) through conventional submerged liquid fermentation or solid-state fermentation. The value of added feed enzymes in promoting growth and efficiency of nutrient utilization is well recognised in monogastric animals. However, the efficacy in animal feed applications depends very much on a completely different set of criteria which are based on the mechanism of action in animal nutrition. In this context, several modes of action have been proposed, namely: 1) hydrolysis of specific chemical bonds in feed stuffs that are not sufficiently degraded by the animals' own enzymes, 2) elimination of the nutrient-encapsulating effect of the cell wall polysaccharides and therefore increased availability of starch, amino acids and minerals; 3) breakdown of anti-nutritional factors that are present in many feed ingredients; 4) solubilisation of insoluble NSP for more effective hindgut fermentation and thus improved overall energy utilisation; and 5) complementation of the enzymes (e.g. amylase, protease, lipase) produced by young animals where, because of the immaturity of their own digestive system, endogenous enzyme production may be inadequate.

In some pig studies reported, there are generally no consistent effects of carbohydrase supplementation on the growth performance of pigs. There are reports of positive response to carbohydrase supplementation especially in diets with which high-NSP cereal grains were used, whereas others reported no improvement on body weight in response to enzymes. Differences in response to performance in these studies could be attributed to differences in the type and quantity of cereal grains used, the age of the animal, the extent of deficiency of limiting nutrient and the extent to which the enzyme increased digestible nutrient content. In young pigs, both the limitations imposed by gut capacity, limiting nutrients, as well as negative consequences of fibrous feedstuffs could make carbohydrase supplementation and essential dietary intervention.

The use of multiple enzyme activities targets different anti-nutritive compounds in feedstuffs to obtain the maximum benefit from the enzyme. However, it is important to understand the optimum combination of enzyme to use in animal diets, in addition, the beneficial effect of enzyme combination may be dependent on diet composition. To maximise the efficacy of enzyme combination, it is essential to understand how the enzyme work together to hydrolyse their respective substrate. For example, because some xylanases target soluble and others insoluble arabinoxylans, the most effective combination is achieved when they are used together. Figure 1 below is a schematic presentation with regard to the interaction of feed enzymes and gut microbiota for the benefit of the animals.

Fig. 1. Link between feed enzymes and gut microbiota in poultry and swine. NSPases, NSP-degrading carbohydrases (adapted from Kiarie *et al.*, 2013)



Application of enzymes in an effort to improve nutrient digestibility of plant-based feed ingredients for pigs and poultry has been studied for decades. However, with large diversity and concentration of chemical characteristics existing among plant-based feed ingredients, as well as interactions among constituents within feed ingredients and diets, improvements in nutrient digestibility and pig performance from adding exogenous enzymes to growing pig diets depends on understanding these characteristics in relation to enzyme activity. Essentially, the enzyme must match the target substrate(s), there may need to be a "cocktail" of enzymes to effectively breakdown the complex matrixes of fibrous carbohydrate structures and there must be some negative role that these substrates have on nutrient digestibility or voluntary feed intake. With the inverse relationship between fibre content and energy digestibility being well described for several feed ingredients, it is only logical that development of enzymes that degrade fibre and thereby improve energy digestibility or voluntary feed intake will have a greater likelihood to be beneficial to improve fibre utilisation in pigs, both metabolically and economically.

Reference available on request.