Gut Health – The key to maximizing pig productivity

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Amongst biotechnological additives, feed enzymes (FE) for pigs have made the most progress and impact in the past decade. Generally, the enzyme systems available for the animal feed industry are derived from microbes (fungi & bacteria) through traditional sub-merged liquid fermentation or solid-state fermentation.

The carbohydrase market is accounted for by two dominant enzymes: xylanases and cellulases. Other commercially available carbohydrases include α-amylase, β-mannanase, α-galactosidase and pectinase. The role of FE in improving the productive value of diets for single-stomached animals has received extensive reviews and in this context, several modes of action have been proposed, namely: **(1)** hydrolysis of specific chemical bonds in feedstuffs that are not sufficiently degraded or indeed not at all by the animal's own enzymes; **(2)** elimination of the nutrient-encapsulating effect of the cell wall polysaccharides and therefore increased availability of starches, amino acids and minerals; **(3)** breakdown of anti-nutritional factors that are present in many feed ingredients (e.g. soluble NSP & phytic acid); **(4)** solubilisation of insoluble NSP for more effective hindgut fermentation and thus improved overall energy utilisation; and **(5)** complementation of the enzymes (for example, amylase, protease, lipase etc.).

The ability to find and evolve the next generation of FE will be driven by understanding the target substrates and the implications to animal nutrition. However, the gastrointestinal tract (GIT) is populated with diverse assemblages of microbiota that play a critical role not only for the overall well-being of the animal, but also its nutrition, performance and quality of its products.

Gut microbiomes: - a complex and dense community of bacteria, archaea, fungi, protozoa and viruses inhibits the gat of the pig. Indeed, the total number of microbial cells within the GIT of single-stomached animals, including man, exceeds that of the host cells by at least one order of magnitude. The GIT microbiome exhibits a gradient concentration, with numbers and diversity increasing from proximal to distal. For example, in pigs, the stomach and proximal small intestine contain relatively low numbers of bacteria ($10^3 – 10^5$ bacteria/g or ml of contents); with dominant bacteria being *Lactobacillus* spp. and *Streptococcus* spp. In contrast, the distal small intestine harbours a more diverse and numerically greater (10^8 bacteria/g or ml of contents) population of bacteria.

A significant hindrance in studying the gut microbiome has been the inability to effectively identify and quantify microbial species, their metabolic end-products and mechanisms by which they affect the host health. This is mainly because the bulk of available information is limited to cultivable microbiota. The fraction of micro-organisms that are cultivable remains low mainly because the growth requirements of most of the bacteria are unknown, but also because of the selectivity of the isolation media that are used, the stress imposed on bacteria by the cultivation procedures, the need for anoxic conditions and problem simulating the microbe-microbe and microbe-host interactions that occur naturally in the gut.

Host-microbe interaction is currently a very active area of research and may help in identifying clusters of GIT bacteria that are consistently associated with better growth performance and health in animals raised in varied environments.

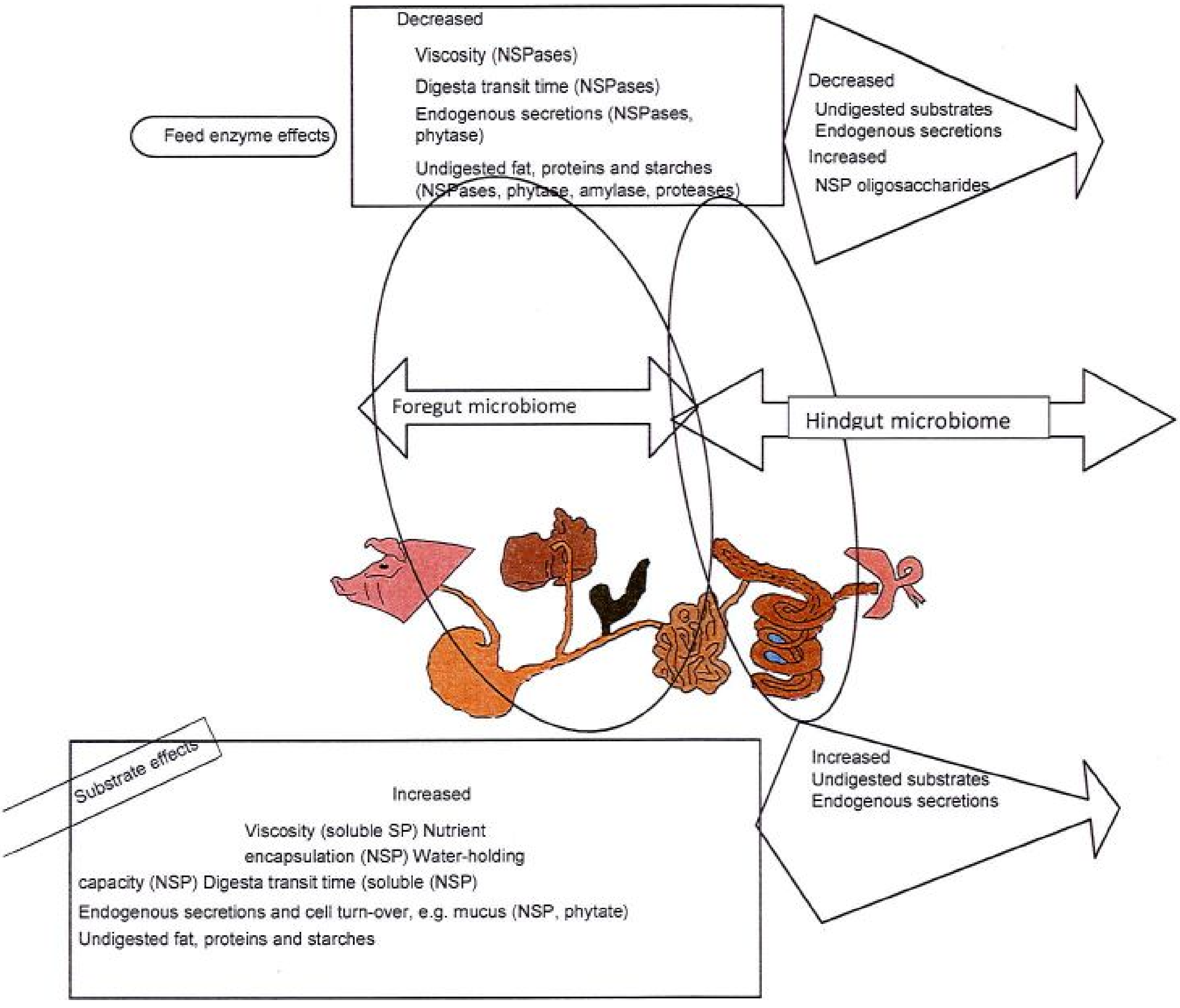
Dietary approaches to gastrointestinal health: - the primary functions of the GIT are to digest and absorb nutrients from the diet and to excrete waste products. However, there are many specific bacterial pathogens that inhabit the GIT and they generally cause disease when the gut ecosystem is disturbed in some manner. For example, in the post-weaning period of pigs, numbers of pathogenic *Escherichia coli* proliferate to exceed those of other bacterial populations, resulting in clinical disease.

The detrimental effects of soluble fibres in pigs have been associated with increasing digesta viscosity, undigested nutrients in the GIT and endogenous secretions. Furthermore, an increased flow of ileal undigestible protein in the hindgut can result in proteolytic fermentation in the large intestine of pigs that can negatively affect their performance and health.

Nutrition and gut health:- an increasing number of trials demonstrate the impact of nutrition makes on the animal's healthy performance. Non starch polysaccharide (NSP) content in pig feed is one key variable as it affects satiety, gut motility, nutrient digestion and absorption, as well as changes in gut microbiota. Arabinoxylan is a key component of the NSP in many raw materials and its varying solubility influences the amount of undigested substrate left to encourage microbial overgrowth. Higher concentrations of both NSP and starch substrates have been associated with an increased incidents of swine dysentery and trials have illuminated the correlation between a diet high in NSPs and non-specific colitis. Even simple corn diets contain arabinoxylans, with levels varying according to harvest and other conditions, so this is an issue for pig producers feeing high fibre diets.

Feed enzymes such as xylanase help break down the insoluble arabinoxylans (hemicellulose) in both maize and wheat-based diet. In addition to reducing digesta viscosity through the hydrolysis of soluble arabinoxylans in the small intestine, certain xylanase generates arabinoxylo-oligosaccharides, which act as prebiotics, selectively stimulating the growth of beneficial bacteria. They also produce short chain fatty acids in the intestine, which can be used as an energy source by the animal.

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



By far estimation most pigs are fed mostly non-viscous maize-based diets; furthermore, quite a great deal of advance have been made in housing equipment and bio-security. Under such production systems it might be difficult for a nutritionist to economically justify an extra dose of FE to cater for gut health. However, a key metric for profitability in pig production is growth performance, which in turn is dependent of variability in animal health and efficient utilisation of feed. FE have a role in increasing uniformity of the herd and thus improving profitability. However, the application of FE to manage poor-performing animals in a herd would perhaps be more precise if such variability impinges on gut microbiota.

The role of FE as part of an integral approach to animal health that is less reliant on antibiotic compounds appears to be important, although more research is needed to further elucidate factors affecting host-microbiome-diet interactions and strategies to alter those interactions in favour of the host.

References available on request.