Feeding a low crude protein diet to maintain intestinal health

Feeding pigs with a low crude protein (LCP) diet is one potential strategy for maintaining the intestinal health of pigs and reducing nitrogen emissions. Both are increasingly important considerations for swine producers.

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Recent evidence has shown that improvement of the intestinal barrier function through a moderate level of dietary protein might be associated with the composition of gut microbiota. At weaning, piglets suffer from nutritional, social, environmental and immunological stresses.

Feeding weaned pigs with a high crude protein (HCP) diet is likely to result in intestinal dysfunction caused by increased hind gut protein fermentation and proliferation of pathogenic bacteria. At this stage, probiotic supplementation might alleviate the risk of HCP diets and increase the benefit of low crude protein (LCP) diets.

Systematic studies addressing whether LCP diets with probiotic inclusion would influence growth performance and gut health are required.

Evonik conducted a study with the Teaching and Research Base of Animal Nutrition Institute of the Sichuan Agricultural University, China. It was designed to evaluate the effects of Bacillus Subtilis DSM32315 (GutCare) supplementation on gut microbiota profile and gut barrier function of weaned pigs fed HCP and LCP diets.

What we did

The 42-day trial involved a total of 72 healthy piglets aged 25 days with an average initial body weight of 7.61±0.55kg.

Piglets were assigned into four treatment groups in a randomised complete block design with a 2 (two protein levels) ×2 probiotic levels (0 or 500mg of GutCare/kg diet added at the expense of corn) factorial arrangement.

The pigs were fed in two phases and the two crude protein levels included HCP (0-14 days, 20.5%; 15-42 days, 19.5%) and LCP (0-14 days, 18%; 15-42 days, 17%).

Each treatment had six replicate pens with three pigs per replicate. A corn-soybean meal-based diet was formulated using the published standardised ileal digestible (SID) coefficients of amino acids and according to the recommended nutrient requirements for pigs weighing 5-10kg and 10-20kg.

All diets were free of antibiotics and all piglets had free access to water and feed.

On days 0, 14 and 42 of the experiment, body weight and feed consumption were recorded. From days 39 to 42, fresh faecal samples were collected.

Faecal samples were dried for analysis to determine the apparent total tract digestibility (ATTD) of nutrients using acid insoluble ash present in the raw materials.

Collecting results

At the end of the experiment, one pig with an average body weight in each pen was euthanised. After the abdomen was opened, ileal and colonic digesta were collected into sterile containers and stored at -80°C until measurement of microbial quantity (quantitative PCR), and short chain fatty acids could be conducted.

The histological samples from jejunum and ileum were rapidly fixed into 10% buffered formalin for villus height and crypt depth determination.

The mucosa of ileum was sequentially obtained through careful scraping of the mucosa layer (flushed with ice-cold saline) with a glass microscope slide, and then snap-frozen in liquid nitrogen for analysing relative mRNA expressions of tight junction-related genes and intestinal development-related genes in ileum of piglets.

The effect of diets on different variables was analysed as a 2×2 factorial with the GLM procedure of SAS.

Increased Bacillus and Bifidobacterium count

The results indicated that supplementation of Bacillus Subtilis DSM32315 increased Bacillus and Bifidobacterium count regardless of crude protein level in ileum. In the colon, the abundance of Bacillus and Bifidobacterium increased in LCP diets when Bacillus Subtilis DSM32315 was supplemented, but this was not the case in the HCP diets.

In addition, adding Bacillus Subtilis DSM32315 had a tendency to increase the Lactobacillus count regardless of the crude protein level in ileum and colon.

As a response to these microbial changes – which are beneficial for the piglets – an increase in propionic and butyric acid production at the large intestine was observed when Bacillus Subtilis DSM32315 was added. Whereas, in ileum an increase in acetic acid production was observed with Bacillus Subtilis DSM32315 only in LCP diets.

The acetic acid produced may be utilised by bacteria, which produce butyric acid through cross-feeding.

The production of short chain fatty acids influences epithelial cell proliferation, which may explain the increase of villus height in jejunum and ileum aided by Bacillus Subtilis DSM32315 supplementation only in LCP diets.

For the villus height: crypt depth ratio (VH:CD), an increase in jejunum was observed by Bacillus Subtilis DSM32315 supplementation regardless of crude protein level, but in ileum this effect was observed only in the LCP diet with Bacillus Subtilis DSM32315.

In ileum, the relative mRNA expression of tight junction-related genes, such as Occludin-1, and intestine tract development related genes, such as EGF and IGF-1R, increased to a greater extent when Bacillus Subtilis DSM32315 was added to LCP diets than to HCP diets.

The relative mRNA expression of ZO-1 and GLCP-2 increased when pigs were fed with Bacillus Subtilis DSM32315 regardless of the crude protein level.

Benefits in the integrity of intestinal barrier function and gut development may be a result of the increase mRNA expression of tight junction and intestinal tract development-related genes, and of the increase of short chain fatty acids production.

As a consequence of a better gut integrity, an increase in the apparent total tract digestibility (ATTD) of dry matter and gross energy by Bacillus Subtilis DSM32315 regardless of crude protein level, and an increase in the ATTD of ether extract in pigs fed Bacillus Subtilis DSM32315 in LCP diets were observed.

Conclusions

Overall, improvements in the microbiota profile and gut integrity were observed when the pigs were supplemented with Bacillus Subtilis DSM32315, especially in the LCP diets.

Bacillus Subtilis DSM32315 altered hindgut bacterial composition, increased short chain fatty acid production, and maintained intestinal barrier function and gut integrity of piglets.

This may be because when pigs were supplied with lower dietary crude protein levels, the amount of undigested protein and amino acids in the hindgut is reduced, therefore, the proliferation of pathogenic bacteria is limited, minimising the risk of post-weaning diarrhoea.

These benefits of supplementation were more pronounced when pigs were fed LCP compared with high protein HCP diets.

These findings offer a potential nutritional strategy to improve gut health for weaned piglets, especially for those producers looking to maintain or improve the intestinal health of their livestock and reduce nitrogen emissions. ■

References are available from the author on request