Probiotics – an innovation in the feeding of swine

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Swine feed formulation today is not only about securing that pigs get the nutrients they require in order to match their requirements for optimal growth performance. It is also about securing that the health status of the pigs is at such a level that they can convert the ingested nutrients into optimal growth.

Swine nutritionists today have a wide range of tools to help them formulate diets that support the health of the pigs, ensuring optimal utilisation of the ingested feed.

One such tool is probiotics, which are live micro-organisms that when administrated in an adequate amount confer a health benefit on the pig.

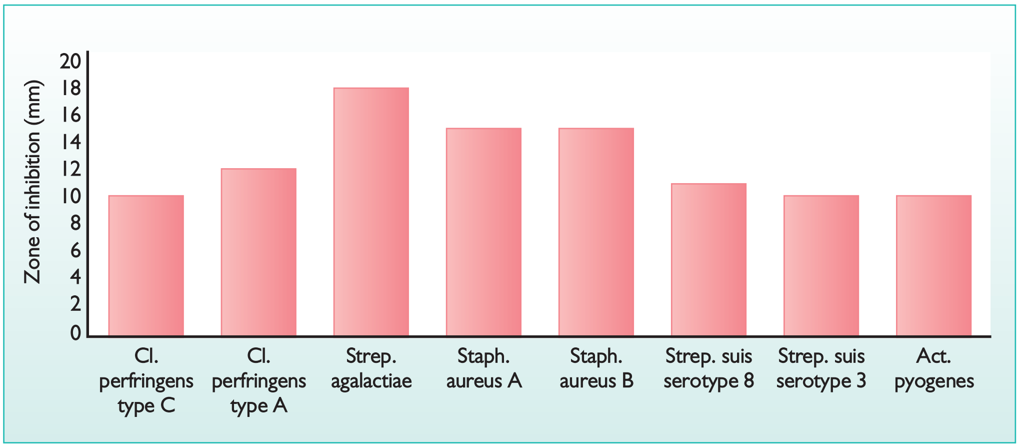


Fig. 2. Zone of inhibition by a probiotic strain of B. licheniformis.

Live micro-organisms

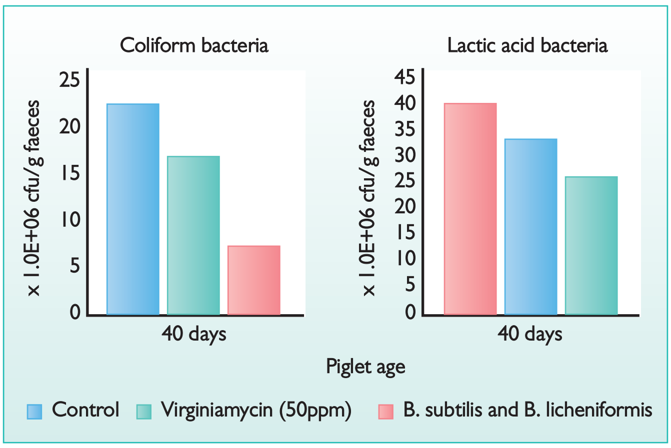
Probiotics are live micro-organisms, typical lactic acid producing bacteria (LAB) such as Enterococcus faecium, live yeast or spore forming bacteria such as the genus Bacillus, administrated to the pigs either orally, through water or in feed.

Danish Pig Production performed a meta-analysis comprising 125 of their trials with feed additives conducted over a period of 25 years.

The feed additives were grouped as acids, oligosaccharides, flavourings, fibres, enzymes and micro-organisms and it was found that micro-organisms or probiotics was the group of additives that led to the largest improvement in feed conversion ratio (FCR). The findings indicate that probiotics are superior in securing intestinal health and optimal functionality of the gastro-intestinal tract (GIT).

Probiotics modulate the composition of the microbial community in the gastro-intestinal tract which is also named the microbiota. The members of the microbiota in swine that draw most attention are the pathogenic micro-organisms, which cause damage of the intestinal epithelia leading to diseases or suppressed production performance.

Fig. 1. Probiotic and AGP modulation of the pig microbiota.



Methods to control the composition of the microbiota have a long track record in swine production.

Herd health management has become a discipline of its own and is in most implementations focusing on structured 'one way' movements of pigs and cleaning programs aiming at minimising the risk of spreading diseases within a production facility.

Medication and vaccination programs designed to target production site specific disease profiles are common practice. Finally, feed additives are used to control and modulate the microbiota. Most common are AGPs (antibiotic growth promoters). But as these are becoming more and more limited in use due to legislation, other additives like minerals, organic acids, prebiotics and probiotics are increasing in use.

Probiotics are known to modulate the microbiota in such a way that the proportion of lactic acid bacteria is increased and the proportion of coliformic bacteria is decreased.

The mechanism of how bacillus increase the number of lactic acid bacteria is not fully understood, but a decreased oxidation-reduction potential caused by germination has been suggested. This mechanism has been shown to benefit lactic acid bacteria. The composition of the microbiota is in this way modulated to be more beneficial for the host animal.

In contrast, the use of antibiotics is reducing the number of bacteria in the GIT, but not affecting the composition of the microbiota (see Fig. 1). Probiotics can, through modulation of the microbiota composition, reduce the number of coliformic bacteria below the level obtained by using antibiotic growth promoters.

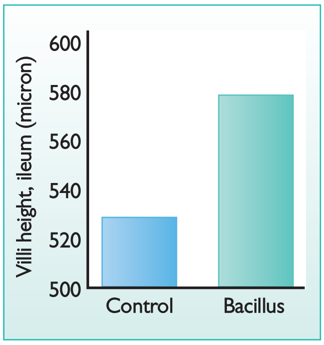


Fig. 3. Effect of Bacillus on villi height.

Besides modulation of the composition of the microbiota some probiotics have a direct inhibiting effect on pathogenic micro-organisms.

This ability is probiotic strain specific so that some strains of the species, say, strains of Bacillus subtilis have this ability, while other strains of Bacillus subtilis do not. This inhibition of specific pathogens can be explained by production of antimicrobial compounds with a narrow range of activity like bacteri-

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ocins, BLIS, bacteriolytic enzymes, organic acids or other lipopeptides. Another known antibacterial effect in vivo is biofilm formation by some specific Bacilli strains.

An example for a probiotic strain of Bacillus licheniformis is shown in Fig. 2 where a zone of inhibition method similar to disc diffusion has been used. These laboratory data are supported by several in vivo trials showing that a combination of a specific Bacillus subtilis and a specific Bacillus licheniformis strain inhibits salmonella, Clostridia perfringens and Streptococcus aureus.

Fig. 2 shows that probiotic strains may inhibit the growth of the main porcine pathogens like Clostridia perfringens, Staphylococcus aureus and Streptococcus suis.

Species	Expected[2] (cfu[1]/g feed)	Mash feed (cfu/g feed)	Pellets (cfu/g feed)	Recovery after pelleting[3](%)
L. farcimis	NA	3.1E+04	<10	<1
P. acidilactici	4.0E+06	3.6E+06	2.7E+04	1
E. faecium	4.0E+06	8.5E+06	1.5E+06	18
S. cereviciae	8.0E+06	8.0E+06	2.7E+04	<1
B. subtilis	1.3E+06	1.2E+06	1.2E+06	100
B. licheniformis	1.3E+06	1.2E+06	1.2E+06	100

[1]Colony forming units [2]claimed CFU/g feed when applied according to label directions [3]85°C in 30 seconds

Table 1. Recovery after pelleting of different probiotic strains.

	B. subtilis & B. licheniformis		No probiotics	
Medication	No	Yes	No	Yes
No. of pigs	198	198	198	198
ADG (g/day) (index)	423 (107)	462 (117)	395 (100)	443 (112)
FCR (index)	1,366 (98.5)	1,350 (97.3)	1,387 (100)	1,353 (97.5)

Table 2. Effects of combining a probiotic and medication program on the performance of nursery pigs.

Microbiota modulation

Modulation of the microbiota by probiotics, in a host beneficial way, has been reported to affect the morphology of the small intestine in pigs. Supplementing pigs with a probiotic based on B. subtilis and B. licheniformis increased the villi height in ileum.

The intestinal epithelium is affected by enterotoxins produced by E. coli as well as by the ammonia concentration in digesta. Both factors are known to reduce villi height and enterocyte cell area. Bacilli based probiotics has been shown to reduce the presence of E. coli through microbiota modulation as well as the ammonia concentration.

This way application of Bacilli based probiotics improve the health of and enhances the absorption capacity of the GIT.

The enhancement of the absorption capacity of the GIT has been shown in digestibility studies showing that the coefficient of digestibility of dry matter, protein and energy are increased when bacilli based probiotics are supplemented to standard non-medicated grower swine diets based on corn and soy (Fig. 4).

The improvements in digestibility shown in Fig. 4 were followed by enhanced rates of retention of dry matter, protein and energy in the study. The improved health and functionality of the GIT by bacilli based probiotics not only led to better digestion of the feed but also to an increased deposition of nutrients in the body of the pig or increased growth and improved feed to gain ratio (FCR).

Probiotics has to be ingested by the pig as live micro-organisms. As the three main genus (LAB; yeast and bacilli) have different properties the choice of probiotic strain has to be considered together with the way of application. The Institute of Biotechnology, Denmark, together with the microbial laboratory LUFA, Germany, compared the heat stability of probiotic products with different probiotic strains. The products were applied to standard Danish pig feed according to label directions.

Samples were collected from mash feed before pelleting (85°C in 30 seconds) and from pellets. The analytical results in term of CFU/g feed and recovery of the probiotic strains after pelleting are shown in Table 1.

A low recovery after the pelleting process was found for the non-spore forming probiotic strains, while full recovery was observed for the spore forming probiotic Bacillus strains. Under practical conditions feed additives including probiotics will often be used together with medication programs. It can be demonstrated that probiotics based on B. subtilis and B. licheniformis have a positive impact on swine performance under such conditions.

Table 2 summarises the results from a 2x2 factorial university study with probiotics and a medication program (110ppm Tylan Sulfa G/tylosin in feeding phase 1 and 2; 55ppm Mecadox/carbadox in feeding phase 3 and 110ppm lincomycin in feeding phase 4) as main factors.

The feed was a standard commercial corn and soy diet with plasma, 2000ppm ZnO and 230ppm Cu. Pigs went on trial after weaning (5.6kg approximately day 21) and were on trial for 45 days.

Without medication supplementation with probiotics improved average daily gain (ADG) by 7% and with medication supplementation with probiotics improved ADG by 4%.

FCR was generally low and only small improvements seen. The features of probiotics are normally used to enhance the productivity of the pigs by applying probiotics as an additive, i.e. on top of a formulated feed. An alternative way of utilising the features of probiotics is to reduce the energy and nutrient concentration in the feed with the aim to obtain 'normal' productivity by feeding a cheaper diet. That is to apply probiotics as an ingredient, with matrix values, in the formulation of diets.

The impact of such an application of a B. subtilis and B. licheniformis based probiotic is shown in Fig. 5. Ninety-six piglets were allocated to three treatment groups. A standard group with feed formulated up against the NRC 1998 requirements. A reduced group where the feed compared to the 'standard' group contained 1.2% less energy and 2% less protein and amino acids and finally a group fed the 'reduced' diets including the recommended amounts of probiotic. Pigs were on trial from 22 to 57 days of age.

Fig. 5 shows that the probiotic applied in the 'nutrient reduced' diet led to a productivity of the piglets similar to or slightly better than the piglets fed the standard diets.

Conclusion

Supplementation with probiotics is an effective way to modulate the microbiota so that the intestinal health is improved to such a degree that GIT functionality, in term of feed degradation and nutrient absorption, is enhanced.

Probiotics based on a combination of Bacillus subtilis and Bacillus licheniformis has been documented to show productivity enhancement as well as synergetic effect when combined with a medication program. Probiotics can also be used in combination with nutrient diluted diets to obtain unchanged productivity at a lower feed cost. ■

Fig. 4. Effect of Bacilli based probiotic on apparent digestibility.

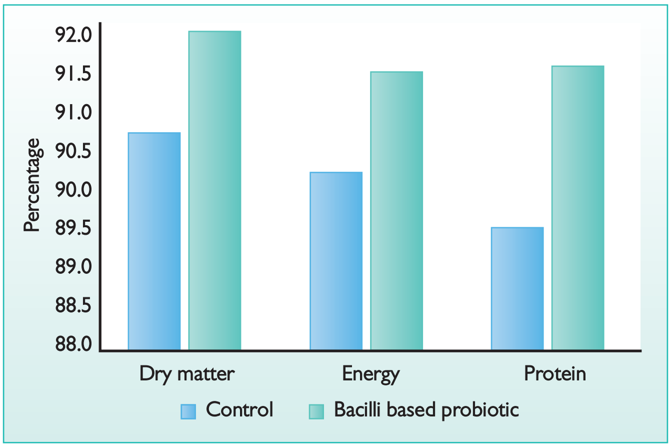

Fig. 5. Effect of probiotic based on B. subtilis and B. licheniformis on gain and feed utilisation when administered in a diet with reduced nutrient and energy concentration.