Effect of Free Medium Chain Fatty Acids on Zootechnical Performances and Health of Piglets After Weaning

It is well known in swine husbandry that the weaning period is the most critical period in a piglet's life. The environmental, nutritional, social and managerial changes that are happening during the weaning period are a real challenge for the piglets. The short-term consequences of facing all these stress factors will be a retarded feed intake and growth, which in the end can lead to diarrhoea and immunity suppression. A lot of farms are using antibiotics to solve those problems but with the general awareness that antibiotic use must go down, alternatives are a necessity. A specific synergistic mixture of medium chain fatty acids is a proven alternative. The antibacterial activity of the medium chain fatty acids and their positive effects on the gut health are already described in several studies. In order to prove that medium chain fatty acids are a worthy alternative, a large amount of trial data is needed. Those trial data have been summarised in a meta-data analysis to show the consistent effect of medium chain fatty acids on technical performance and health in weaned piglets.

Improving Gut Health is Key

Maintaining good gut health is essential for low antibiotic use and good growth performances. As gut health is an extremely complex matter, no clear definition is available. However, it is clear that gut health is an interaction between the diet, the gut mucosa and the gut microflora which should provide effective digestion and absorption of the feed, the absence of gut diseases, a stable gut microbiota and an effective immune status.

The importance of a healthy gut cannot be underestimated. The gut surface is 200 times higher than the skin surface. And this surface has an extremely difficult and contradicting function: absorbing nutrients as efficiently as possible, while reducing the entrance of noxious substances as much as possible. As the gut contains, in fact, 10 times more bacteria than the number of body cells, this is an extremely difficult task! In this way it is not strange that 20-35 % of the energy and amino acid requirements of the pig go to the gut. As 70 % of the immune cells are concentrated around the gut, it is clear that gut health is also essential to improve immunity of the animals. The importance of gut health is also widely recognised in academic research. In 1999, 250 articles were published on gut health of pigs. Last year, in 2015, this number increased to over 750 articles.

Taking all of this into account, it is clear that reducing antibiotic use is only possible by maintaining good gut health. Of course, gut health is difficult to measure, but improved gut health can easily be seen in technical and health parameters. Examples are: improved growth performance, reduced FCR, less prevalence of pathogens (*E. coli, Brachyspira, Lawsonia, Salmonella*), improved immunity, lower need for antibiotic use, and lower mortality.

Medium Chain Fatty Acids as Gut Microbiota Regulator

Medium chain fatty acids (MCFAs) are saturated fatty acids consisting of aliphatic tails of total chain length of either six (caproic acid), eight (caprylic acid), 10 (capric acid) or 12 (lauric acid) carbon atoms and a polar head. The use of free (so not coated, micro-encapsulated or esterified) MCFA as a functional feed ingredient is an effective way to reduce antibiotic use in pigs. Free MCFAs provide an early pathogen barrier in the stomach of the animal. This is an advantage over MCFA esterified mono-, di- and triglycerides, which are only gradually active in the intestinal tract after endogenous lipase releases the free MCFA molecules.

In the low pH environment of the stomach, un-dissociated MCFAs are capable of penetrating the phospholipid bilayer of the bacterial cell membrane, thereby destabilising it. This results in leaking of bacterial cell content on the one hand, and entering of MCFAs into the bacterial cells on the other hand. Inside the bacterial cell, MCFAs encounter a near-neutral environment, resulting in accumulation of dissociated MCFA molecules and protons in the bacterial cytoplasm. Dissociated MCFAs will intercalate with the bacterial DNA, thereby inhibiting DNA replication and thus bacterial growth. Intracellular acidification and inhibition of DNA replication will eventually lead to killing of the bacterium. Thanks to their specific chemical properties, medium chain fatty acids have a much higher antimicrobial activity compared to other acids. MCFAs clearly show lower minimal inhibitory concentrations (MIC) when compared to short chain and long chain fatty acids (Table 1).

Bacterial strain	Propionic acid	Butyric acid	Formic acid	MCFA
Bacillus cereus	>10	>10	>10	2.5
Campylobacter jejuni	5	5	5	0.5
Clostridium perfringens	5	>10	2.5	0.5
Enterococcus faecalis	>10	>10	>10	2.5
Escherichia coli	>10	>10	>10	5
Salmonella enteritidis	>10	>10	>10	5
Staphylococcus aureus	5	>10	>10	2.5
Brachyspira hyodysenteriae	>10	>10	>10	2.5

Table 1: Minimal inhibitory concentrations (MIC) of different organic acids for different bacteria, expressed in g/kg

Not only do these medium chain fatty acids kill pathogens, they also alter virulence of pathogens. Even at non-bactericidal concentrations, MCFAs can have a dramatic effect on pathogen persistence. By reducing the virulence of bacterial pathogens like *Clostridium* and *Salmonella*, the outcome of disease is altered and intestinal and systemic colonisation is reduced, as shown

in scientific trials.

The combination of these antibacterial actions makes sure that the beneficial microbial system of the gut will be largely unaffected. MCFAs clearly shift the balance in the gut from Enterobacteriaceae to the beneficial Lactobacilli in the ileum of piglets (Figure 1).

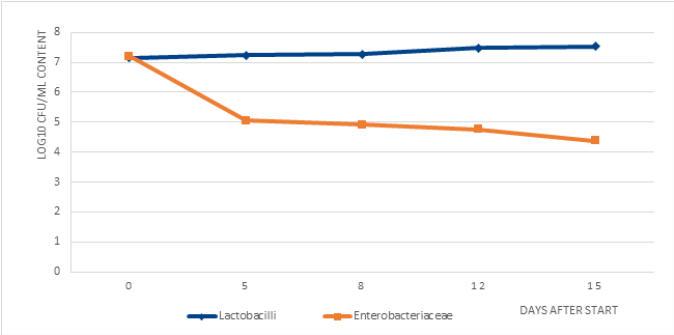

Figure 2: MCFAs clearly shift the balance in the gut from Enterobacteriaceae to the beneficial Lactobacilli in the ileum of piglets

Medium Chain Fatty Acids Boosting Animal Health

The latest discovery is that medium chain fatty acids don't only improve gut health, they also significantly improve the immunity of animals. Numerous pieces of research have shown that the viability of neutrophils is reduced enormously under stress conditions. Stress conditions are frequently occurring in highly productive animals these days: sows around farrowing, piglets around weaning, but also fatteners growing at high growth rates, and this not always in optimal conditions. Research showed that medium chain fatty acids significantly increase the neutrophil quality in animals. White blood cells (neutrophils) remain more active, making the animal also more resistant against non-digestive disorders. This was also shown at the University of Wageningen, where the use of medium chain fatty acids was the only additive ever tested that gave a significant reduction of the number of veterinary treatments due to lung problems (Table 2).

	Negative control	AMGP	MCFA	Significance
Amount of pigs	220	220	190	
Number of animals treated with antibiotics	26	23	13	n.s.
Reason for treatment:				
Streptococcus infections	5	2	1	a
Pulmonary disorders	7	7	0	*
Digestive disorders	5	0	1	a
Leg problems	8	12	10	n.s.
Others	1	2	1	a

n.s. = not significant, * = significant, a = numbers too low to test significance

Table 2: Effect of MCFAs on veterinary treatments in piglets after weaning (8-20 kg)

Medium Chain Fatty Acids Boosting Pig Performances: A Meta Analysis

Field trials, involving 5244 piglets of different genetics, have been carried out in different countries (Belgium, Spain, Germany, France, the Netherlands, England and Australia). All trials started at day 1 after weaning until the piglets had an end weight of 20-25 kg. Half of the piglets in the trials were given a diet containing 2 kg/ton of a specific mixture of MCFA; the other half of the piglets can be divided into negative and positive control groups. In trials against a negative control group, the MCFAs were just added on top of the regular diet. In trials against a positive control group, the MCFAs replaced antibiotics, zinc oxide, probiotics or organic acids. The main parameters measured in the trials were average daily gain (ADG), feed conversion ratio (FCR) and mortality. The meta-data analysis for ADG contains 18 trials, including nine negative and nine positive trials. For FCR and mortality respectively, 15 (seven negative and eight positive control groups) and 10 trials (six negative and four positive control trials) were taken into account.

The meta-data results are compiled in Table 3. The control group consists of animals from both the negative and positive trials. Overall, with MCFA, the daily gain was significantly improved from 352 to 370 g/day, an increase of 5.2 %. Significant differences were also found for the average feed conversion ratio and mortality. The average feed conversion ratio improved from 1.54 to 1.49 kg/kg (-3.5 %) and the mortality was lowered 1.6 %. With these better technical results, it was calculated that the total return of investment was 3.8.

Treatment	# trials	Control	MCFA	% positive trials	P -Value
# animals		2622	2622		
ADG (g/day)	18	352[a]	370[b]	89%	< 0.0001
FCR (kg/kg)	15	1.54[a]	1.49[b]	73%	< 0.014
Mortality (%)	10	3.8[a]	2.2[b]	80%	<0.034
ROI			3,8 *		

Table 1: Meta-data analysis: Average growth performances of piglets after weaning till 20-25 kg

* The reduction in medication cost was not taken into account

Effect of MCFA on ADG

Figure 3 aligns the 18 trials where ADG was measured. Trials 1 to 9 are trials with MCFA against a negative control group. Trials 10 to 18 are trials against a positive control group. The MCFA group showed an average improvement of 25 grams/day compared with the negative control group and an improvement of 11 gram/day compared with the positive control group. In 16 out of the 18 trials, MCFA resulted in a better ADG.

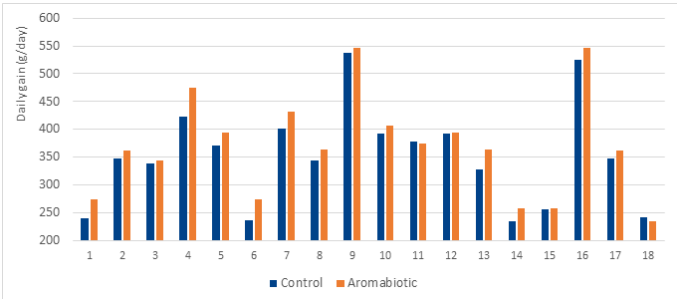

Figure 3: Meta-data analysis: Effect of MCFA on ADG

Effect of MCFA on FCR

Figure 4 shows the effect of MCFA on the feed conversion ratio against negative and positive trials. The first nine trials are negative control trials. Trials 9 to 15 are positive control trials. Against the negative control, an average

improvement was measured of 0.04 kg/kg. Compared with the positive control groups, an improvement of 0.06 kg/kg was performed. In 11 out of the 15 trials, an improvement was noted with MCFA.

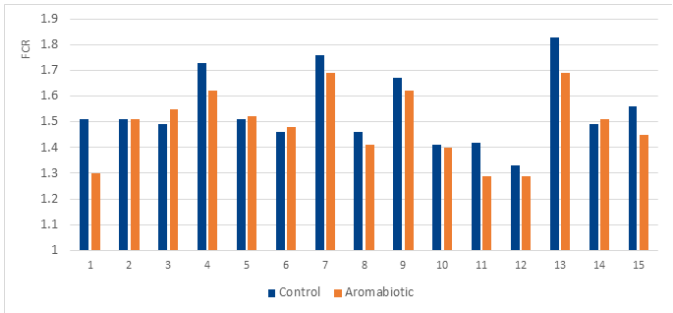

Figure 4: Meta-data analysis: Effect of MCFA on FCR

Effect of MCFA on Mortality

Figure 5 shows the effect of MCFA on the mortality of the piglets. Trials 1 to 6 are negative control trials. Trials 7 to 10 are positive control trials. A reduction of respectively 1.8 % and 1.3 % was measured for the negative and positive control groups. In 8 out of the 10 trials there was a reduced mortality.

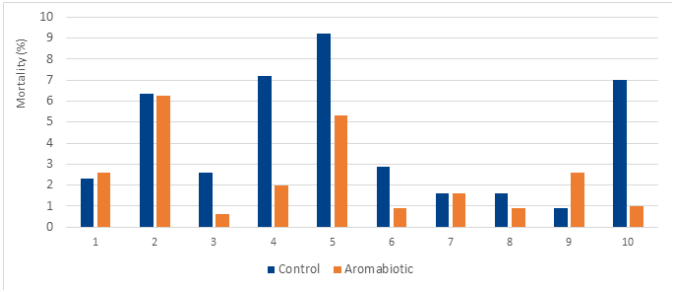

Figure 5: Meta-data analysis: Effect of MCFA on mortality

Conclusion

With strongly increasing insights in genetic selection, today's sows, piglets and fatteners possess an enormous genetic potential which cannot be kept up by standard nutrition. On top of this, the reduced use of antibiotics creates the need for reliable alternatives. It is clear that the broad spectrum activity and mode of actions of medium chain fatty acids make them an ideal solution to reduce antibiotic use. Not only can they reduce the antibiotic use, they even have add-on effects when used together with antibiotics. In this way they can reduce the duration of the antibiotic treatment, and gradually reduce the antibiotic use in time.

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