In situ production of prebiotics: making prebiotics in the animal itself

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Background
In animal husbandry, infectious disease is commonplace and antibiotics are routinely used in large amounts. The aim of this project was to develop a feed supplement as an alternative to antibiotics in the form of a prebiotic feed which could increase bacterial diversity and beneficial bacteria since these can combat pathogens in the GI-tract.

Because of the current cost-effectiveness of antibiotics, novel products should be effective as well as very low-cost, which current prebiotics are not. In this endeavour, the production of prebiotics was moved from the industrial setting to instead take place within the gastrointestinal tract of the animal, which is what we refer to as in situ production of prebiotics (figure 1). We used a waste product from the potato industry, namely potato pulp, along with pectinolytic enzymes to release galactose rich rhamnogalacturonan 1.

In vitro studies
In an in vitro digestion, 24.6% of the potato pulp could be water solubilized by enzymes and this solubilized galactose-rich fraction (rhamnogalacturonan 1) was then fermented by bacteria present in contents from piglet terminal ileum. The fermentations resulted in high levels of organic acids as determined by HPLC, lactate in particular, and an increase in the Genera Lactobacillus and Veillonella determined by deep sequencing of the 16S rRNA gene, suggesting some prebiotic potential.

In vivo studies
When enzymes in combination with potato pulp were then fed to weaning piglets, we found up to 40% of the theoretically maximum amount of solubilized fiber in the gastrointestinal content. This was released within 20 minutes, suggesting that in situ production of fiber is feasible (figure 2).

In vivo infection
A pilot study testing an experimental infection was performed by feeding the pulp and enzyme supplement to weaning piglets challenged with E. coli F4+. Enzyme-released fibers as well as microbial changes (figure 3) were observed in the intestines of the animals but the experimental challenge unfortunately did not result in a clinical infection.

In conclusion
Overall, in situ production of fibers is possible in the weaning piglet, although it remains to be confirmed in vivo if these fibers are indeed prebiotic and/or inhibitory against PWD.

References

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Figure 1: The in situ catalysis concept. 1) Enzymes and substrate is given along with feed. 2) Concomitantly with regular digestion, the catalysis is initiated in the stomach and/or the small intestine. 3) The produced fiber travels to the ileum and colon where it acts as a prebiotic.

Figure 2: When enzymes along with potato pulp where administrated in vivo, we observed release of rhamnogalacturonan 1 within 20 minutes, suggesting that in situ production is feasible in the weaning piglet. Values are means ± 30% and 4-6 real assers from the center. CH1510 is carbohydrate larger than 1000Da.

Figure 3: rRNA multivariate plot of the fecal and ileal microbiome across an experimental infection as assayed by 16S Illumina sequencing. Large points are infected animals.