RESEARCH ABSTRACT

ENVIRONMENT

Title: Alternative feedstuffs for reducing ammonia and odor emissions in pork production systems and improving the pig's gut health – **NPB #06-117**

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Scientific abstract

Nutrition can help reduce the impact of pork production on the environment and improve pig gut health. The formulation of diets based on highly-digestible feedstuffs and using diets that meet the exact requirements of the pigs, considerably reduces the excretion of minerals such as nitrogen and phosphorus into the environment. The presence of fermentable dietary fiber in the diet can also reduce the emission of gaseous nitrogenous compounds by shifting nitrogen excretion from urine to feces. It is also believed that fermentable dietary fiber can improve gut health by favoring the development of health-promoting bacteria such as Lactobacilli, at the expense of pathogenic ones. The present project is aimed at quantifying the effect of dietary fiber composition on both N excretion and gut health.

The overall objective of the project was to evaluate alternative feedstuffs for their potential impact on the character of manure excreted, on the formation of odor-causing compounds and on the gut health of the pig. More specifically, it aimed at screening a series of alternative feedstuffs for their ability to enhance colonic fermentation and thus reduce the emission of ammonia and other odor-causing compounds and to improve the gut health of the pig by favoring the development of a beneficial microflora at the expense of a pathogenic one. The evaluation was conducted using both in vitro and in vivo studies.

The first experiment focused on gut health. In particular, we wanted to see if it was possible to take advantage of the variation in non-starch polysaccharides (NSP) and starch composition of a specific ingredient in order to improve gut health. Barley was used as a model for two reasons. First, it is widely used in swine nutrition. Secondly, its carbohydrate composition is extremely variable. For example, there are hulled and hulless barleys. The latter have extremely variable contents of β-glucan, a soluble polymer of glucose (41 to 84 g β-glucan/kg) and amylose/amylopectin ratios (40/60% to 0/100%). Oats were used as a reference.

Seventy two weaned piglets were allocated to one of nine diets composed of 81.5% cereal, 6% whey, 9% soy protein isolate and 3.5% minerals. The cereals were: hulled barley, hulled barley supplemented with 2.3 or 4.6% β-glucan, 4 hulless barleys with different β-glucan content (from 41 to 84 g/kg) and 2 oat varieties. After 15d, pigs were killed and ileum and colon contents collected for analysis (short-chain fatty acids, ammonia, lactic acid and pH) and DNA extraction.

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Quantitative polymerase chain reaction (qPCR) and a nested PCR-Denaturing Gradient Gel Electrophoresis (PCR-DGGE) approach were used to evaluate the microbial communities.

The analysis of fermentation metabolites in the intestines showed lower pH values in the colon of pigs fed with hulless barleys. No marked differences between cereals were observed at the ileum level, with the exception of lower contents in lactic acid in the ileum of pigs fed oats ($P < 0.03$) and higher short chain fatty acids (SCFA) content ($P < 0.01$). At the colonic level, lower SCFA and ammonia contents ($P < 0.001$) were observed in pigs fed oats and higher contents in lactic acids were obtained in pigs fed the hulless barleys ($P < 0.001$).

Graded shifts in both, ileal and colon microbial communities were observed with the hulless barley varieties/lines with normal to high β-glucan content. These hulless barley varieties/lines had the lowest ($P < 0.05$) microbial diversity in the colon; whereas oat varieties had intermediate diversity compared with low β-glucan hulless varieties/lines and hulled varieties with or without β-glucan supplementation. DGGE band identification suggested hulless high β-glucan varieties/lines favored xylan and β-glucan degrading bacteria whereas β-glucan supplemented hulled barley favored the growth of lactobacilli. Enumeration by qPCR revealed a decrease of lactobacilli, enterobacteria and streptococci in the ileum with hulless/high β-glucan diets. Our results show that both form (purified supplement versus grain matrix) and quantity of dietary cereal β-glucan are important factors affecting changes in gut microbial composition in the pig.

Pig gut health was improved through feed formulation, an indication of “prebiotic effects” of hulless barleys and high β-glucan content. The results will help to develop future feeding strategies.

The second experiment was designed to compare the effect of non-conventional feed ingredients differing in dietary fiber and protein content on N excretion in pigs. Altogether 64 weaned pigs (average initial weight 24 kg) were fed with one of 8 diets. The feedstuffs included in the experimental diets were wheat bran, cellulose, peas, pea inner fiber, pea hull fiber, sugar beet pulp, flaxseed meal and corn Distiller's Dried Grains with Solubles (DDGS). The diets were balanced in energy and amino acids with soy protein isolate, pea starch, sucrose and a premix. Fecal samples were collected for 3 consecutive days from d10 and pigs were slaughtered on d16. Digesta from ileum and colon were collected at the ileal and colonic levels and analyzed for their short-chain fatty acids (SCFA) and ammonia content. The digestibility of the nutrients was estimated by means of chromium oxide (Cr_2O_3) at the ileum level and acid insoluble ash at total tract level, which in turn was used to calculate nitrogen excretion from the pigs.

Taking wheat bran as the reference diet, the total tract digestibility of N was lower in pigs fed with flaxseed meal and DDGS (72% and 74% respectively) and higher with pea hulls (81%) and pea inner fiber (79%). This, in turn affected the fecal N excretion. The latter was higher with diets containing flaxseed meal and DDGS (280 and 262 g/kg N intake respectively). Diets based on peas and pea hulls had higher ($P<0.05$) SCFA (39 and 27mMol/kg digesta) at ileum, while no difference ($P > 0.05$) in SCFA concentration was observed among diets in colon. In colon, higher ammonia concentration was found in peas, PHF, FSM and DDGS based diets fed pigs. The results of the study suggest that both the fermentable fiber and protein level in the diet affect the ammonia concentration in the intestines and fecal nitrogen excretion. Although it was not measured here, a shift in nitrogen from urine to feces can be expected in pigs fed sources of highly fermentable dietary fiber such as peas or pea hulls, which reduces ammonia emission. On the contrary, no effect of dietary fiber was observed on the emission of butyric acid, a malodorous compound.

Finally, the economic impact of the incorporation of sources of fermentable dietary fiber for the reduction of ammonia emission in the environment was evaluated. Based on the current feed costs and the properties of some dietary fiber sources, it can be concluded that a reduction in the level of crude protein in the diet is more efficient than the use of fiber sources, with the possible exception of citrus pulp, which has a good nutritional value, is cheap and has demonstrated interesting properties for the reduction in ammonia emission.