

The effect of different feed ingredients on fermentation metabolites and nitrogen excretion in pigs

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SUMMARY

There is growing interest for including dietary fibre (DF) in pig diets due to its potential health benefits and possible contribution to a reduction of nitrogen (N) excretion from the swine production facility. Different ingredients could be used as the source of DF in swine diets. An experiment was conducted to evaluate the influence of different DF sources with varying indigestible protein (iCP) on bacterial fermentation and associated metabolites (short-chain fatty acids, SCFA) production, and N excretion when used

“Peas and pea-fibres reduced nitrogen excretion and could possibly contribute to improving the gut health of pigs”

in swine diets. The sources of DF and its iCP content had a major effect on accumulation of ammonia in the colon and N excretion. Peas and pea-fibre based diets decreased N excretion and enhanced bacterial fermentation and SCFA production in the intestine of pigs. Thus, peas and pea-fibres could be considered for swine nutrition, in order to reduce N excretion and potentially improve gut health of pigs, compared to other ingredients studied.

INTRODUCTION

Fermentation of both dietary fibre (DF) and protein in the pig intestine is a matter of interest for pig nutritionists due to their possible beneficial or harmful effect on gut health and the environment. Fermentable fibres constitute a source of energy for the pig after their fermentation and transformation to SCFA. Fibre fermentation can also lead to a decrease in ammonia concentration in the gut because of fixation of N in the bacterial proteins. Inclusion of fermentable fibre in swine diets reduces protein fermentation along the gastrointestinal tract, which can mitigate the negative impact of protein fermentation on pig health. However, most of these functional properties have been observed with isolated fibres and fermentation characteristics of fibre

depend on how they are presented: in isolated form or embedded within the whole matrix of the feed. Moreover, adding DF just for its fermentative properties is not economically viable. A more pragmatic approach would consist in using feed ingredients that present desirable functional properties.

Many feed ingredients with high fermentable DF are also rich in iCP, which can interact with the positive effects of the fermented DF. However, there is limited information available on these possible interactions, our hypothesis is that both the non-starch polysaccharide (NSP) content and the CP:NSP ratio in the diets affects the SCFA and ammonia concentration in the pig intestine as well as N excretion.

Thus, this study was conducted with different sources of DF with varying levels of iCP to evaluate the interactions between DF and CP and their effect on N excretion and the fermentation metabolites concentration in the intestine of pigs.

MATERIALS AND METHODS

Sixty-four growing pigs were used in a completely randomized experiment where one pig was the experimental unit. They were weaned at 21 days and reared with their littermates in nursery rooms. At 6 weeks of age (average body weight 24.1 ± 3.1 kg), the pigs were moved to individual pens, with free access to water and randomly allocated to one of the 8 experimental diets with 8 piglets/diet. No antibiotics (prophylactic or therapeutic) were administered to the animals during the study. Diets were manufactured using wheat bran (WB), wood cellulose (Solka-floc®, SF), peas, pea hulls (PH), pea inner fibre (PIF), sugar beet pulp (SBP), flaxseed meal (FSM) or corn distillers dried grains with solubles (DDGS) as test ingredients. The diets were balanced in energy and amino acids with soy protein isolate, pea starch, sucrose and a vitamin-mineral premix. Faecal samples were collected for 3 consecutive days from d10 and pigs were slaughtered on d16. Digesta from ileum and colon were collected and analyzed for their SCFA and ammonia content.

RESULTS AND DISCUSSION

The coefficient of apparent total tract N digestibility (Table 1) was lower in diets based on FSM, DDGS and peas (0.72, 0.74 and 0.75, respectively), medium in diets with WB and SBP (0.76 each) and higher in those with SF, PIF and PH (0.78, 0.79 and 0.81, respectively). Expressed per kg fermented NSP, N excretion was higher with DDGS, WB and FSM diets (130, 113 and 109 g/kg NSP fermented, respectively) and lower with peas, PH, PIF and SBP diets. The pea- and pea hulls-based diets had higher ($P < 0.05$) SCFA concentrations (39 and 27 mMol/kg digesta, respectively) at the ileum level, while no difference ($P > 0.05$) in SCFA concentration was observed between diets in the colon.

Table 1. Apparent digestibility coefficients of nutrients and nitrogen excretion in pigs fed diets differing in fibre and protein source

Diet	CIAD		CTTAD		Nitrogen Excretion		
	DM	N	DM	N	g/kg DM intake	g/kg N intake	g/kg NSP fermented
Wheat bran	0.68	0.71	0.78 ^{bc}	0.76 ^{abcd}	6.9 ^b	237 ^{abcd}	113 ^{ab}
Solka flocc [®]	0.67	0.77	0.77 ^c	0.78 ^{abc}	7.1 ^{ab}	217 ^{abcd}	102 ^b
Peas	0.77	0.71	0.88 ^a	0.75 ^{bcd}	7.0 ^b	251 ^{abc}	64 ^c
Pea Hull	0.75	0.78	0.89 ^a	0.81 ^a	6.5 ^b	191 ^d	42 ^c
Pea inner fibre	0.70	0.77	0.88 ^a	0.79 ^{ab}	6.5 ^b	206 ^{cd}	42 ^c
Sugar beet pulp	0.73	0.79	0.87 ^a	0.76 ^{abcd}	7.6 ^{ab}	236 ^{abcd}	55 ^c
Flax seed meal	0.65	0.65	0.82 ^b	0.72 ^d	7.4 ^{ab}	280 ^a	109 ^{ab}
Corn DDGS	0.72	0.76	0.78 ^{bc}	0.74 ^{cd}	8.3 ^a	262 ^{ab}	130 ^a
SEM			0.103	0.123	0.40	12.2	505
P-Value			<0.001		0.049		<0.001

Abbreviations: CIAD/CTTAD, coefficient of apparent ileal/total tract digestibility; DM, dry matter; N, nitrogen

*Mean values with different superscript within column differ ($P < 0.05$)

Table 2. Fermentation metabolites in the colonic digesta of pigs fed diets differing in fibre and protein source

Diet	pH	SCFA ⁺	NH ₃ ⁺	% of total SCFA ⁺			
				AA	PA	BA	BCFA
Wheat bran	6.65 ^a	94.1	99.5 ^{abc}	63.6	19.6 ^b	12.4	2.8
Solka flocc [®]	6.17 ^{ab}	112.9	87.6 ^{abc}	61.8	18.0 ^b	16.3	2.1
Peas	5.97 ^b	113.9	126.5 ^{ab}	55.9	21.0 ^{ab}	16.5	2.6
Pea Hulls	6.13 ^{ab}	121.6	132.1 ^a	57.8	21.0 ^{ab}	15.3	2.6
Pea inner fibre	6.03 ^b	119.0	68.1 ^c	59.9	24.1 ^a	11.9	2.0
Sugar beet pulp	5.96 ^b	112.5	73.3 ^{bc}	61.1	21.8 ^{ab}	13.5	2.0
Flax seed meal	6.66 ^a	101.4	129.1 ^a	61.5	21.6 ^{ab}	11.5	2.8
Corn DDGS	6.37 ^{ab}	100.0	106.3 ^{abc}	60.5	22.1 ^{ab}	11.8	2.8
SEM	0.13	6.97	12.3	1.86	0.95	1.84	0.29
P-Value		0.076	<0.001	0.126	0.003	0.276	0.204

Abbreviations: AA, acetic acid; BA, butyric acid; BCFA, branched-chain fatty acids (the sum of iso-butyric and iso-valeric acids); NH₃⁺, ammonia; PA, propionic acid; SCFA, short chain fatty acids

⁺ mMol/kg digesta sample

*Mean values with different superscript within column differ ($P < 0.05$)

A higher (Table 2) ammonia concentration was also found in the colon of pigs fed with PH, FSM, and peas (132, 129 and 127 mMol/kg digesta, respectively). There was lowest N excretion with peas and pea-fibre based diets when expressed per unit of NSP fermented.

The CP:NSP ratio in the diets and ammonia concentration were positively correlated here ($r=0.47$, $P < 0.001$). The same was observed between the NSP level and the ammonia concentration ($r=0.46$, $P < 0.001$) in the colon. This supports our hypothesis that both the NSP content and the CP:NSP ratio in the diets affect the ammonia concentration in the pig intestine. A lower ammonia concentration obtained for the PIF diet indicates a reduction in bacterial hydrolysis of nitrogenous compounds in the presence of highly fermentable fibre in the matrix.

CONCLUSION

The results of the present study show that peas and pea-fibre based diets enhanced bacterial fermentation and SCFA production in the intestine of the pig which had less N excretion as well. The fermentation process can be attributed to both source and level of fibre and indigestible protein content in the diets, in addition to DF and CP interaction. Moreover, the sources of DF and its indigestible protein content and the ratio of CP:NSP had a major effect on accumulation of ammonia in the colon and N excretion.

IMPLICATIONS

Peas and pea-fibres could be considered for swine nutrition, in order to reduce N excretion and possibly contribute in improving gut health of pigs, compared to other ingredients studied.

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Peas