Impact of fibre on performance and intestinal health of pigs fed a high indigestible protein level

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APPLICATION FOR PRODUCERS

Talk to your nutritionist about the addition of a fibre blend in your nursery diets to improve gut health, especially if you feed diets high in indigestible protein.

SUMMARY

Dietary indigestible protein (IDP) may be a better indicator of potential negative dietary effects than total protein. This is likely because IDP is available as substrate for microbial fermentation in the hindgut resulting in the production of harmful metabolites. Fermentation of fibre, on the other hand, is generally considered to result in production of beneficial metabolites and may benefit piglets fed high dietary IDP content. This study examined the effect of fibre blend in nursery pigs fed a high dietary IDP level on performance and intestinal health. Piglets were fed a high level (3.8%) of indigestible protein, either without fibre supplementation (IDP4), or with supplementation of one of four dietary fibre fractions (DFF) at different ratios of soluble (SDF) to insoluble (IDF) fibre (1:1, 1:3, 1:5, and 1:7 for DFF1, 2, 3, and 4, respectively).

Although there was no effect on growth performance, fibre fraction supplementation improved fecal consistency score, reduced diarrhea incidence, and improved certain parameters of gut health. Overall, the results suggest that the addition of fibre, regardless of soluble to insoluble ratio, has a beneficial impact on piglet gut health in nursery pigs fed high IDP levels.

INTRODUCTION

It is still unclear what factors are primarily responsible for the negative response to high protein diets. While there is a general trend for reduced incidence of diarrhea with decreasing dietary protein content, this is not consistent across studies when examining the same protein content, suggesting a factor other than simply total dietary protein content is involved, such as protein type or indigestible protein (IDP) content. A meta-analysis of existing literature suggested that dietary IDP may be a better indicator of potential negative dietary effects than total protein. Considering IDP is a measure of the amount of protein that is not digested in the small intestine, an increase in dietary IDP suggests a greater amount of protein that is available as substrate for microbial fermentation in the hindgut resulting in the production of harmful metabolites such as branched-chain fatty acids, ammonia, biogenic amines, phenols, and hydrogen sulphide.

Unlike with protein, fermentation of fibre is generally considered to result in production of beneficial metabolites, such as short-chain fatty acids, that promote gut health and limit pathogen growth. As with protein, the impact of dietary inclusion of fibre on nursery pig performance and intestinal health has been inconsistent, likely due to differences in the physicochemical properties and fermentability of different fibre sources. Inclusion of a non-structural/soluble fibre source may provide intestinal bacteria an alternative substrate for fermentation whereas inclusion of a structural/insoluble source of dietary fibre may reduce the impact of indigestible protein through increased digesta flow through the gut and reduced adhesion of pathogens.

This study was the first to examine the effect of fibre content in pigs fed a high dietary indigestible protein level. The overall goal of this study was to provide mitigation strategies to mitigate negative effects of indigestible protein and enhance the ability to utilize feedstuffs common in Saskatchewan while improving sustainability of pork production.

EXPERIMENTAL PROCEDURES

After weaning (d25), piglets were fed a high level (3.8%) of indigestible protein, either without fibre supplementation (IDP4), or supplemented with dietary fibre fractions (DFF) at 4 different ratios of soluble (SDF) to insoluble (IDF) fibre (1:1, 1:3, 1:5, and 1:7 for DFF1, 2, 3, and 4, respectively), using fructo-oligosaccharide (inulin®) as SDF and lignocellulose (opticell® C2) as IDF.

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Growth performance was measured weekly. Fecal samples were collected weekly to score for diarrhea as follows: 1. Normal (solid/firm); 2. Pasty (semi-solid); 3. Moderately fluid (loose); 4. Highly fluid (watery). A score above 2 was considered as diarrhea. On d 9 and 28, myeloperoxidase (MPO) activity, a pro-inflammatory bio-indicator, was determined on fecal samples. On d 9, one mid-weight pig was selected per pen, bled to collect blood samples, and eviscerated to obtain intestinal tissues, digesta, and fecal samples.

RESULTS AND DISCUSSION

Pigs fed high IDP without fibre had higher fecal consistency score (FCS, $P < 0.001$) and were observed to have diarrhea (score >2) throughout the experimental duration (Figure 1A). Among pigs consuming DFF diets, FCS showed linear and quadratic responses (linear, $P = 0.049$; quadratic, $P = 0.049$), with consistently lower FCS observed in pigs fed DFF 2, 3, and 4. Diarrhea incidence was significantly higher in pigs fed IDP4 compared to all DFF pigs (treatment, $P = 0.002$; contrast, $P < 0.001$; Figure 1B). There was linear and quadratic effect of DFF on diarrhea incidence (linear, $P < 0.001$; quadratic, $P < 0.001$). There was no effect of DFF supplementation on fecal MPO level.

From d22 to d28, pigs fed IDP diets without fibre (IDP4) tended to have greater feed intake (ADFI), weight gain (ADG) and feed efficiency (G:F) than pigs fed IDP diets with DFF supplementation. However, there was no effect of fibre fraction supplementation on overall ADFI, ADG, and G:F.

Plasma redox and inflammatory biomarkers (MDA, D-Lac, SOD, GPx, DAO, haptoglobin, and MPO), serum biomarkers of acute-phase response (IL-6, IL-1β, and ALB, respectively), and plasma urea nitrogen (PUN) are presented in Table 1.

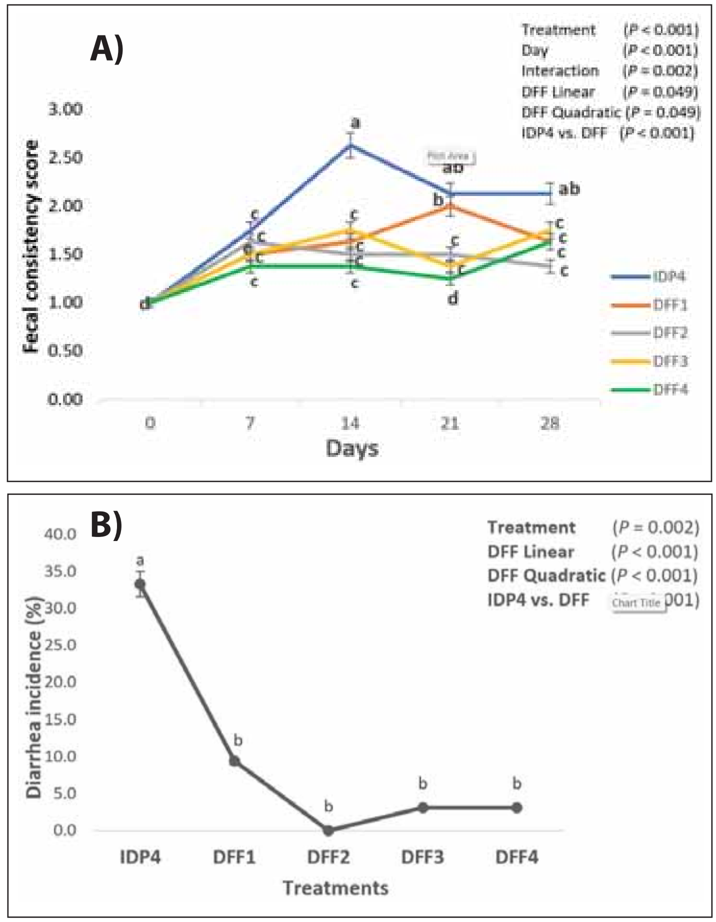

Figure 1. Fecal consistency score (A) and percentage diarrhea incidence (B) in piglets fed a high level (3.8%) of indigestible dietary protein, either without (IDP4) or with supplementation of one of four dietary fibre fractions (DFF) with different ratios of SDF:IDF (1:1, 1:3, 1:5, 1:7 for DFF1, 2, 3, and 4, respectively). The diarrhea incidence was calculated using the following equation; Diarrhea incidence (%) = (number of pens with diarrheic pigs / total number of pens per treatment) × 100. Treatments with different superscripts differ ($P<0.05$).

Table 1. Blood parameters of piglets fed a high level (3.8%) of indigestible dietary protein, either without (IDP4) or with supplementation of one of four dietary fibre fractions (DFF) with different ratios of SDF:IDF (1:1, 1:3, 1:5, 1:7 for DFF1, 2, 3, and 4, respectively).

Parameters[1]	Treatments					Day		SEM[2]	P-values					
	IDP4	DFF1	DFF2	DFF3	DFF4	d9	d28		Trt	Day	Interaction	DFF Lin.[3]	DFF Quad.[4]	IDP4 vs. DFF[5]
MDA, mol/µL	0.37	0.34	0.40	0.33	0.33	0.30b	0.41a	0.02	0.659	0.049	0.526	0.646	0.648	0.636
Plasma MPO, nmol	248	246	245	241	233	243	243	2.13	0.362	0.968	0.612	0.097	0.097	0.253
PUN, nmol/µL	227	217	223	240	242	243a	216b	3.95	0.235	0.040	0.635	0.031	0.031	0.709
D-Lac, nmol/µL	15.1	16.7	18.0	16.5	14.4	22.0a	10.3b	0.87	0.330	0.002	0.528	0.142	0.143	0.351
SOD, U/mol	2.04ab	1.92b	1.91b	2.55a	2.05ab	2.25a	1.93b	0.07	0.029	0.077	0.255	0.122	0.124	0.666
GPx, nmol/min/ml	53.9	54.1	55.6	53.3	52.3	44.0b	63.7a	1.40	0.768	0.001	0.656	0.347	0.347	0.980
DAO, mU/mL	0.91	0.92	0.91	0.90	1.06	1.19a	0.69b	0.06	0.881	0.020	0.537	0.475	0.475	0.804
Haptoglobin, g/L	1.35	1.15	1.19	1.11	1.19	1.70a	0.69b	0.09	0.774	0.004	0.174	0.961	0.960	0.239
IL-6, ρg/mL	26.8a	21.4b	22.5ab	22.9ab	23.0ab	26.5a	20.1b	0.55	0.022	0.005	0.765	0.265	0.265	0.002
IL-1β, ρg/mL	8.15a	6.70ab	6.53b	6.45b	6.59b	5.87b	7.90a	0.19	0.024	0.007	0.991	0.797	0.797	0.002
ALB, g/L	48.8	45.8	46.5	42.3	46.1	49.1a	42.7b	4.26	0.186	0.025	0.587	0.663	0.666	0.102

[1] MDA, Plasma malondialdehyde; MPO, Myeloperoxidase; PUN, Plasma urea nitrogen; D-Lac, D- Lactate; SOD, Plasma superoxide dismutase; GPx, Plasma glutathione peroxidase; DAO, Plasma diamine oxidase; IL-6, Serum interleukin-6; IL-1β, Serum interleukin-1β; ALB, Serum albumin
[2] SEM, Standard Error Mean
[3] Linear response
[4] Quadratic response
[5] Contrast; IDP4 versus all DFF treatments

SOD, IL-6, and IL-1β were influenced by dietary treatments. Plasma SOD was highest in DFF3-fed pigs, lowest in DFF1 and DFF2 pigs with IDP4 and DFF4 being intermediate. Serum IL-6 and IL-1β were more elevated in pigs fed IDP4 compared to DFF diets (contrast; P = 0.002). Serum IL-6 was observed to be lowest among pigs fed DFF1, while IL-1β was lowest among pigs fed DFF 2, 3, and 4. Contrary to PUN, plasma MPO showed linear and quadratic tendencies to increase with DFF levels (linear, P = 0.097; quadratic, P = 0.097).

Both cecal and colonic ammonia-nitrogen concentration was greater for IDP4 pigs than pigs fed DFF diets (treatment, P <0.001; contrast, P <0.001; Table 2). However, there was no linear and quadratic effect of DFF on cecal and colonic NH3-N concentrations.

IMPLICATIONS

The results suggest that the addition of fibre, regardless of soluble to insoluble ratio, has a beneficial impact on piglet gut health.

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Table 2. Cecal and colonic ammonia-nitrogen (NH3-N) concentration of piglets fed a high level (3.8%) of indigestible dietary protein, either without (IDP4) or with supplementation of one of four dietary fibre fractions (DFF) with different ratios of SDF:IDF (1:1, 1:3, 1:5, 1:7 for DFF1, 2, 3, and 4, respectively).

Parameters[1]	Treatments					SEM[1]	P-values			
	IDP4	DFF1	DFF2	DFF3	DFF4		Treatment	DFF Lin.[2]	DFF Quad.[3]	IDP4 vs. DFF[4]
Cecal NH3-N, µg/mL	2947a	1717b	1771b	1838b	1827b	47.84	<0.001	0.441	0.442	<0.001
Colon NH3-N, µg/mL	2509a	1833b	1987b	1984b	1962b	31.23	<0.001	0.251	0.251	<0.001

[1] SEM, Standard Error Mean
[2] Linear response
[3] Quadratic response
[4] Contrast; IDP4 versus all DFF treatments