Impacting Greenhouse Gas Emissions Through Diet Change

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Western Canada, wheat millrun, a co-product of wheat milling is commonly added to swine diets, reducing diet cost and competition with humans for cereals. The inclusion of wheat millrun in swine rations is limited by the high non-starch polysaccharide (NSP; dietary fibre content), Fibre is not digested by pigs, and thus nutrient availability is limited. Carbohydrase enzymes can be added to possibly improve the digestibility of wheat millrun by breaking down the fibre more effectively. This would increase the feeds' energy value and reduce undigested matter in the feces, allowing for low-quality raw materials to be included in swine diets.

Animal protein demand is increasing which will raise greenhouse gas (GHG) production/emissions, exacerbating environmental problems including climate change, unless mitigation steps are implemented. Although pork production accounts for less than 10% of GHG emissions from the livestock sector, the predicted growth in global pork consumption makes mitigation efforts essential. Understanding the impact of non-conventional ingredients in swine diets on the environment is important; specifically how they may alter manure output and GHG emissions. Increasing dietary fibre may increase hindgut fermentation and the production of GHG emissions, but might not affect performance of the pigs when a multi-carbohydrase enzyme is supplemented.

This study focused on how to further reduce the GHG emissions by pigs without negatively impacting efficiency or productivity.

Specific objectives were:

- To determine the response of growing pigs to wheat millrun inclusion in diets, with or without, a multi-carbohydrase enzyme.
- To determine the impact of wheat millrun inclusion supplemented with a multi-carbohydrase in swine diets fed to grow-finishing pigs on GHG production from the pigs and manure.

What We Did

Performance and digestibility

Forty-eight barrows with an initial body weight of 60±2.2 kg were used for the digestibility study. Pigs were randomly assigned to one of six dietary treatments with 8 pigs per treatment. Treatments included wheat millrun (none, low, high; 0, 15 or 30 % respectively) with or without the multi-carbohydrase enzyme. The feed was divided into two equal meals and presented at 0830 and 1500 hrs. Pigs were allowed free access to water throughout the experiment. Urine and feces were collected for analysis.

One hundred and eighty pigs with an initial body weight of 60.2 ± 2.2kg were randomly assigned to one of the four experimental treatments which included a control diet (no millrun), and 30 % wheat millrun inclusion with and without carbohydrase enzymes, with five pigs per pen and nine pens per treatment. Pigs were provided a common diet for at least five days prior to the start of the experiment. Weight was recorded along with feed disappearance throughout the experiment. Pigs were sent to an abattoir once a minimum of 128 kg was achieved and slaughter characteristics were analyzed.

Greenhouse gas measurements

Ninety-six pigs with an initial body weight of 60±2.2 kg were assigned to one of four dietary treatments (described above). There were four replicates (six pigs per replicate) for each treatment. Gases were sampled and analyzed and manure was stored to measure volume and emissions.

What We Found

Apparent total tract digestibility

The apparent total-tract digestibility (ATTD) of dry matter (DM), energy, nitrogen and phosphorus were linearly reduced with increasing wheat millrun inclusion in the diets, while enzyme supplementation reduced the ATTD of DM and energy. Further, increasing the inclusion of wheat millrun in the diets linearly reduced the digestible energy (DE) and net energy (NE) contents of the diets while enzyme supplementation tended to reduce dietary DE and NE contents. Enzyme supplementation, however, did not affect the ATTD of nitrogen and phosphorus total tract digestibility.

Growth performance

The effects of 30% wheat millrun and carbohydrase supplementation on performance of growing pigs are presented in Table 2. Including wheat millrun in the diets tended to reduce the body weight for day 42 and the final body weight resulting from reduced average daily gain (ADG) on days 29 to 42 and overall. Similarly, for days 29 to 42 of the experiment, the gain to feed ratio (G:F) was reduced in pigs receiving wheat millrun. There was a reduction in the overall G:F (Table 2) when pigs were fed diets

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Table 1: Effect of wheat millrun inclusion and multi carbohydrase supplementation on apparent total tract digestibility of energy and minerals of diets fed to grower pigs (60kg) in Exp1a

	Millrun, %				Enzyme		P- value		
Item	0	15	30	SEM	No	Yes	SEM (Millrun)	Enzyme	Linear
Total tract digestibility									
DM, %	86.5	84.7	83.9	0.28	87.3	82.8	0.22	<0.01	<0.01
Energy,%	87.3	84.9	81.5	0.01	85.0	84.2	0.01	0.05	<0.01
DE, Mcal kg-1	3.50	3.47	3.34	0.01	3.45	3.42	0.01	0.08	<0.01
NE, Mcal kg-1	2.46	2.44	2.34	0.01	2.43	2.40	0.01	0.06	<0.01
Total tract digestibility, %									
N	86.4	85.3	83.5	0.53	85.1	85.0	0.44	0.89	<0.01
P	52.6	43.5	41.1	0.60	46.2	45.2	0.52	0.33	0.02

SEM; standard error of means
No interaction between millrun and enzyme (P > 0.10)
aValues are means of eight individually housed pigs

Table 2: Effect of dietary wheat millrun and multi carbohydrase supplementation on performance of growing pigs over time in Exp2 (60 kg)a

	Millrun, %		Enzyme		Pooled	P- value	
Item	0	30	No	Yes	SEM	Millrun	Enzyme
BW, kg							
Initial	60.1	60.3	59.8	60.6	1.27	0.63	0.10
d 14	76.0	75.8	76.1	75.6	1.12	0.92	0.62
d 28	92.1	91.6	91.9	91.8	0.71	0.50	0.88
d 42	107.3	105.8	106.6	106.4	1.03	0.10	0.84
Final	120.6	118.9	119.6	120.0	0.72	0.10	0.69
ADG, kg d-1							
d 7 to 14	1.13	1.10	1.16	1.08	0.07	0.68	0.14
d 15 to 28	1.16	1.13	1.13	1.15	0.04	0.28	0.42
d 29 to 42	1.09	1.02	1.05	1.05	0.04	0.03	0.90
d 43 to 56	0.94	0.95	0.91	0.98	0.04	0.91	0.11
d 0 to 56	1.10	1.07	1.09	1.08	0.02	<0.05	0.65
ADFI, kg d-1							
d 7 to 14	2.47	2.47	2.47	2.47	0.12	0.98	0.98
d 15 to 28	2.84	2.88	2.87	2.86	0.06	0.60	0.91
d 29 to 42	2.88	2.94	2.87	2.95	0.07	0.58	0.42
d 43 to 56	3.19	3.31	3.20	3.30	0.26	0.24	0.32
d 0 to 56	2.85	2.90	2.85	2.90	0.05	0.41	0.51
G:F							
d 7 to 14	0.45	0.45	0.47	0.43	0.02	0.74	<0.05
d 15 to 28	0.41	0.39	0.40	0.40	0.02	0.19	0.68
d 29 to 42	0.38	0.35	0.37	0.36	0.01	<0.01	0.38
d 43 to 56	0.32	0.30	0.31	0.30	0.01	0.34	0.91
d 0 to 56	0.39	0.37	0.38	0.37	0.01	0.01	0.20

No interaction between millrun and enzyme (P > 0.10)
aData are means of 9 replicate pens with 5 pigs per pen.
SEM; standard error of mean

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with 30% millrun inclusion. However, wheat millrun inclusion had no effect on average daily feed intake (ADFI). Enzyme supplementation on the other hand reduced G:F during the initial 14 days of the experiment, but had no effect on the overall G:F, body weight, ADG or ADFI.

Carcass traits
Wheat millrun inclusion or multi-carbohydrase supplementation did not affect days to market, market weight, slaughter weight, loin depth or dressing percentage (Table 5). Backfat depth was reduced by 7% while carcass yield increased with the inclusion of 30% wheat millrun. Enzyme supplementation tended to increase backfat depth but had no effect on days to market, market weight, slaughter weight, loin depth, carcass yield and dressing percentage (Table 3).

Greenhouse gas measurement
Emission rates are presented in Table 4. Feeding pigs with 30% wheat millrun included in their diets had no effect on the three GHG's measured in this experiment. The highest concentration of gas emitted was CO2 at 1162 and 1336 µg m-3s-1, without or with wheat millrun inclusion respectively, followed by methane (9.1 vs 11.0) and nitrous oxide (0.34 vs 0.40).

Pigs fed 30% wheat millrun diets consumed around 18% more water than pigs fed the zero wheat millrun diets. Total manure output was increased by about 1.2 L pig-1 day-1 when pigs consumed the 30% wheat millrun diets.

Discussion
Most of the fibre constituents in wheat millrun are insoluble xylose and arabinose. These NSPs comprise the cell wall and act as a "physical barrier" that "traps" nutrients and prevents them from being utilized. The function of the carbohydrase enzyme is to breakdown this barrier, releasing the trapped nutrients for utilization by the pig.

The amount of fibre and type of fibre in diets also may affect the efficacy of enzymes. In the hindgut, soluble dietary fibre is more fermentable than insoluble dietary fibre and this may have contributed to the unaffected DE digestibility results found in the experiment as the wheat millrun contains high insoluble dietary fiber. Energy and DM digestibility were reduced in the multi-carbohydrase supplemented diets. The results were supported by the reduced G:F in the first 14 days with enzyme supplementation in the performance study. The negative impact on nutrient digestibility and growth could be due to the digestive enzyme secretion or activity being affected with the supplementation. These results are likely due to the higher NSP content in the wheat millrun diets compared to the diets containing no wheat millrun.

Table3: Effect of wheat millrun inclusion and multi carbohydrase supplementation on carcass traits in Exp2

	Millrun,		%Enzyme		Pooled	P- value	
Item	0	30	No	Yes	SEM	Millrun	Enzyme
Days to market	68	69	69	68	2.57	0.46	0.31
Final BW, kg	132.25	131.81	132.05	132.01	0.41	0.42	0.94
Slaughter weight, kg	105.84	105.10	105.38	105.56	0.54	0.19	0.75
Backfat depth, mm	16.71	15.54	15.74	16.50	0.75	<0.01	0.07
Loin depth, mm	66.82	68.41	67.97	67.27	1.05	0.28	0.63
Carcass yield, %	61.80	62.42	62.29	61.94	0.36	0.01	0.13
Dressing, %	80.03	79.74	79.80	79.96	0.28	0.35	0.60

SEM; standard error of means
No interaction between millrun and enzyme (P > 0.10)

Table 4: Greenhouse gas emissions as affected by wheat millrun inclusion and multi carbohydrase supplementationa

	Millrun,		%Enzyme		Pooled	P- value	
Item	0	30	No	Yes	SEM	Millrun	Enzyme
Gas, µg m-3s-1							
Methane	9.10	11.00	8.90	11.20	1.10	0.27	0.18
Nitrous oxide	0.34	0.40	0.35	0.39	0.05	0.23	0.44
Carbon dioxide	1162	1336	1254	1244	116	0.15	0.93

No interaction between millrun and enzyme (P > 0.05)
a values are means of 4 replicates (chambers) with 6 pigs per chamber.
SEM; standard error of mean

We expected wheat millrun inclusion to decrease dressing percentage because of its lower digestibility and the subsequent increase in the total empty weight of the gastrointestinal tract. However, dressing percentage was not significantly different. Although the energy content in the wheat millrun diets were lower, they were not low enough to elicit a change in the eating behavior of the pigs; so the pigs had similar feed intake as those with diets containing no wheat millrun. The lower energy intake (6.89 Mcal NE/day vs 7.01 Mcal NE/day) by pigs on the wheat millrun inclusion diets might have been responsible for the 7% reduction in backfat depth since this is mainly influenced by the energy intake in the finishing phase. Carcass yield is mainly influenced by backfat depth and pigs with high backfat depth are penalized; so it is not surprising that carcass yield increased with wheat millrun inclusion diets, as the pigs fed those diets had lower backfat.

The high fibre content and low digestibility of the 30% wheat millrun inclusion diets resulted in a higher manure output. Due to the limited activity of endogenous enzymes in the large intestine, most of the fibre in high fibre diets are not completely fermented and are excreted in the feces. The source of CO2 is mainly from animal respiration. The CO2 from the pig is more likely to be influenced by pig activity and less from the manipulation of the diets. Methane emissions from pigs are known to be just 50% of what is produced from manure. Methane emissions (production) from the manure are supported by several factors such as the temperature, organic matter content and pH. The 30% wheat millrun inclusion diets did not affect N2O emissions. Research has shown that N2O emissions are mainly influenced by the age of the manure. Also N2O emissions are related to the excretion of nitrogen, so a reduction of nitrogen in the manure could result in a potential reduction of N2O during the storage of manure.

Conclusions

Supplementing the multi-carbohydrase enzyme apparently reduced energy digestibility but did not change the growth performance of growing-finishing pigs. Up to 30% inclusion of wheat millrun reduced both nutrient digestibility and growth performance. However, days to market was not affected by having 30% wheat millrun inclusions in the diets. Backfat depth had a decrease and carcass yield increased with wheat millrun inclusion. There were no interactions found between wheat millrun inclusion and multi-carbohydrase supplementation on nutrient digestibility, growth performance and carcass quality characteristics.

The 30% inclusion of wheat millrun in swine diets did not affect GHG emissions from swine barns. Even though wheat millrun inclusion increases the fibre content in swine diets, addition of up to 30% of wheat millrun will not significantly increase the GHG produced by the pigs in swine barns.

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