Investigation of Saskatoon berry pomace for mitigation of AMR in swine production

Brenna Stephens[1], Darren Korber[2], Denise Beaulieau[1], and Bernardo Predicala[3, 4]

Bernardo Predicala

INSIGHT FOR PRODUCERS

Fruit pomace, a byproduct of juice production, contains phytochemicals which may enhance animal health and performance. Use of byproducts from other production chains is also a cost-effective way to enrich diets.

SUMMARY

Pomace, the pressing remains of fruit, is known to be rich in phytochemicals, such as polyphenolic compounds, which possess anti-inflammatory, anti-bacterial, anti-fungal, and/or anti-oxidative properties. These characteristics may protect the gastrointestinal tract (GI) and act as an alternative to in-feed antibiotics. The aim of this project examined the effects of saskatoon berry pomace on overall pig performance and health. A pilot-scale study involved feeding pigs' diets with two levels of dried Saskatoon berry pomace to determine its appropriate inclusion rate in the diet and its impact on growth performance, nutrient digestibility, and nitrogen retention. Experimental treatments were Diet A (control, fed a basal diet), Diet B (basal diet plus 5% pomace), and Diet C (basal diet plus 10% pomace). Results indicate Diet C had an improved ($p < 0.05$) total dietary fiber and insoluble dietary fiber digestibility while Diet B had higher ($p < 0.05$) total nitrogen loss compared to Diet A. Both Diets B and C had higher ($p < 0.05$) fecal nitrogen loss compared to Diet A. Overall, a basal diet with 10% pomace (Diet C) improved total fiber and insoluble fiber digestibility and repartitioned nitrogen losses.

INTRODUCTION

Concerns about antimicrobial resistance (AMR) have led to the ban on in-feed growth-promoting antibiotics. Finding new strategies and cost-effective alternatives to antibiotics for maintaining health and achieving production goals are a significant importance to Canadian pork producers.

The gut microbial ecosystem is essential for normal nutritional, physiological, and immunological functions of the animal. Any disturbance in the microbial ecosystem also creates an opportunity for pathogenic organisms to colonize and cause disease. A number of typical barn practices such as early weaning, diet modifications, prophylactic and sub-therapeutic antibiotic use disturb the gut microbial ecosystem, predisposing pigs to disease.

Fruit processing by-products (i.e., pomace) are feed additives that have previously led to substantial improvements in pig performance (Ajila et al., 2015). Pomace, in particular, represents an excellent source of phenolic compounds. These compounds may act as growth promoters by enhancing digestive enzyme secretions and by decreasing the pathogenic microorganisms in the GI or by modulating gut morphology due to their anti-oxidant and anti-inflammatory functions. In a study by Kafantaris et al. (2018), piglets fed with a diet supplemented with grape pomace had higher average daily weight gains and greater numbers of facultative probiotic and lactic acid bacteria compared to those in a control group.

A recent research project showed that continued use of antibiotics in swine production operations increased the frequency of AMR genes, whereas the implementation of a Raised Without Antibiotics (RWA) production program resulted in lower frequency of AMR genes but higher abundance of pathogenic microorganisms. Including pomace into swine diets, while eliminating antibiotics, offers an approach to maintain or improve overall animal productivity without negatively impacting the supply of clinical drugs for human or animal therapeutic use. It can also provide a value-added stream for the fruit-processing industry by diverting waste.

The outcomes of this project are anticipated to contribute to the development of a novel effective approach to eliminating or reducing the use of antibiotics in the livestock industry without compromising productivity and welfare. The reduction of antibiotic drug use in livestock production, combined with the utilization of plant by-products, is expected to translate into decreased production costs.

1 Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Drive, Saskatoon SK S7N 5A8
2 Department of Food and Bioproduct Sciences, University of Saskatchewan, 51 Campus Drive, Saskatoon SK S7N 5A8
3 Department of Chemical and Biological Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon SK S7N 5A9
4 Prairie Swine Center Inc., PO Box 21057, 2105 – 8th Street East Saskatoon SK S7H 5N9

EXPERIMENTAL PROCEDURES

A total of 24 barrows determined to be healthy with no prior conditions or treatments and an initial BW of 35 ± 2 kg were used in this trial. The trial was conducted over two consecutive blocks, each utilizing 12 pigs for a total of 14 days. Pigs were randomly assigned to one of the three treatment groups; Diet A was a basal mash diet with 0% Saskatoon berry pomace (SBP, Control diet), Diet B was basal mash with 5% SBP inclusion and Diet C was a basal mash with 10% SBP inclusion.

Pomace and Feed

Pomace is produced by drying the mash, including the seeds and skin, remaining after juicing. The mash byproduct was dried under low heat (50-80°C) and then milled twice, first to 40 (0.042 cm) and then 80 (0.018 cm) mesh. The final product is dried SBP, not containing any other components, the nutritional content of the SBP can be found in Table 1.

The diets fed were typical Western Canadian swine diets formulated to meet nutrient requirements for pigs of the weight range used, according to the NRC (2012). Celite was used as the marker for the diets. Dietary treatment ingredients and chemical compositions can be found in Table 2.

Table 1. Dried Saskatoon berry pomace analysis and composition according to the manufacturer**.**

Composition	Amount on an as-fed basis
Moisture (g/100g)	6.80
Protein (g/100g)	7.25
Total fat (g/100g)	3.56
Saturates (g/100g)	0.63
Trans fat (g/100g)	<0.03
Cholesterol (mg/100g)	<1.02
Carbohydrate (g/100g)	79.11
Fibre (g/100g)	32.21
Sugars (g/100g)	37.31
Ash (g/100g)	3.28
Vitamin A (RE/100g)	10.35
Vitamin A (IU/100g)	103.48
Vitamin C (mg/100g)	<2.93
Calcium (mg/100g)	560.00
Iron (mg/100g)	3.35
Sodium (mg/100g)	<10.00
Calories (per 100g)	377.48
Magnesium (mg/100g)	160.00
Anthocyanins (mg/100g)	204.00
Total phenolics (mg/100g)	773.00

Note: This table was obtained from the manufacturer packaging label (Prairie Berries, unpublished data).

Table 2. Ingredient and chemical composition of the three treatment diets expressed as a percent (%) as fed basis.

Composition	**Treatment**		
Ingredients (%)	**A**	**B**	**C**
Barley 10.0% CP	46.54	46.54	46.54
Wheat 13.0% CP	15.70	15.70	15.70
Corn 8.0% CP	13.28	13.28	13.28
Soybean meal 45.0% CP	11.27	11.27	11.27
Canola meal 36.0% CP	10.00	10.00	10.00
Vegetable oil	0.30	0.30	0.30
DL-Methionine 99.0%	0.04	0.04	0.04
L-Threonine 98.5%	0.11	0.11	0.11
Coarse calcium	1.03	1.03	1.03
Potash salt bagged	0.52	0.52	0.52
Copper sulfate 25%	0.04	0.04	0.04
Vitamin and mineral premix	0.17	0.17	0.17
Calculated chemical composition (%)			
DM	95.33	95.16	95.07
OM	90.81	90.83	90.87
CP	19.32	18.51	18.53
EE	2.60	2.78	3.55
TDF	20.75	21.95	24.00
IDF	17.05	17.85	20.30
SDF	3.70	4.10	3.75
Anthocyanins (total)	0.00	0.01	0.02
Polyphenols (mg/100g)	0.00	0.04	0.07

Note: The anthocyanins and polyphenols listed in the chemical composition were taken from the manufacturer label from the SBP, the mash diet was not individually tested for either. Vitamin and mineral premix contain the following per kg of diet: 714 mg phytase, 0.30 mg selenium, 1.0 mg iodine, 8000 IU vitamin A, 1500 IU vitamin D3, 30 IU vitamin E, 2.0 mg vitamin K3, 1.0 mg vitamin B1, 4.0 mg vitamin B2, 20 mg niacin, 12 mg pantothenic acid, 2.0 mg vitamin B6, 0.10 mg biotin, 0.50 mg folic acid, 0.02 mg vitamin B12. Diets contains 0.55% BioLys 60, 0.06% Mintrex zinc, 0.02% Propath iron, 0.40% celite.

Note[2]: DM = dry matter; OM = organic matter; CP = crude protein; EE = ether extract; TDF = total dietary fiber; IDF = insoluble dietary fiber; SDF = soluble dietary fiber.

Sample Collection

The sample collection occurred during the last 4 days of each block. Urine samples were collected over days 11-12, and fecal samples were collected over days 11-14 to avoid potential day-to-day variability.

Feed samples were taken from the three treatment diets during every round of mixing feed, and each time a new feed bag was opened. Samples were pooled prior to analysis.

Laboratory Analysis

Feed, fecal, and urine samples were analyzed for crude protein (CP) using the Kjeldahl method, while fecal and urine analysis determined the overall excreted nitrogen content. Fecal and feed samples were analyzed for gross energy (GE) in cal/g. Feed samples were also analyzed for ether extract (EE) or crude fat.

RESULTS AND DISCUSSION

Growth performance

There was no significant difference between treatment groups in any of the growth performance parameters. There is a tendency for pigs fed basal diet (Diet A) to have a higher ADFI than those fed basal diet with 5% SBP inclusion (Diet B; p= 0.06). This may be due to the unfamiliarity of SBP as a feed ingredient causing a decreased initial feed intake as they became adapted to the diet. This is not seen in pigs fed diet C, with a 10% pomace inclusion which contradicts the previous assumption. An alternative rationale may be that the addition of the SBP within the diet, the nutrient content might exceed that of the control diet or allowed for a more efficient absorption of nutrients. This would allow for the pigs to consume less feed while still absorbing required amount of nutrients for growth.

Antioxidants and Polyphenolic Content

Table 3 shows the measured amount of antioxidant capacity (AC) and polyphenols contained in the feed for each treatment diet. The basal diet (Diet A) had more antioxidant capacity to mitigate oxidative stress conditions, without any pomace present in the diet, compared to diets with pomace (Diets B and C). In addition, Diet B had more antioxidant capacity to mitigate oxidative stress conditions than Diet C. Both results were unexpected due to the amount of pomace inclusions. This could be due to a sampling error as Diet C was expected to have the highest amount of AC and total phenolic content (TPC), followed by Diet B and then Diet A to contain the least amount of AC and TPC due to the rate of SBP supplementation. The TPC in all diets was too minimal to determine any differentiation between the diets with the analysis used, all containing less than 2mg/g.

Table 3. Amount of antioxidant capacity and phenolic content of each treatment on an as fed basis.

	Treatment		
Antioxidant parameter	**A**	**B**	**C**
ORAC (umol Trolox equivalent/g)	37.05	32.40	34.10
TPC (mg/g)	<2.00	<2.00	<2.00

Note: A = basal diet; B = basal+5%SBP; C = basal+10%SBP.

Digestibility and Nitrogen

The effects of SBP inclusion on nutrient digestibility and digestible energy (DE) are shown in Table 4. There were no significant differences between treatment groups in the amount of gross energy (GE), however there was a tendency for Diet A to have a higher GE digestibility than Diets B and C (P<0.1). There was a significant difference in dry matter (DM) digestibility between Diets A and B, and a tendency for Diet A to have a higher DM digestibility rate than Diet C (p= 0.07). Average total dietary fiber (TDF) and insoluble dietary fiber (IDF) digestibility was significantly higher in Diet C than in Diet B. There was no significant difference in soluble dietary fiber (SDF) digestibility between treatment groups. Average crude protein (CP) digestibility was significantly higher in Diet A than in Diets B and C. There was no significant difference in DE or DE on a DM basis between treatment groups. Overall, Diet B had the worst performance regarding digestibility. These results display potential for further investigation as Diet C, supplemented at 10% of the diet had the highest overall fiber digestibility while maintaining the growth performance when compared to basal Diet A. Though long-term effects have not been determined, supplementing 10% of grower diets with SBP may be able to improve fiber utilization and absorption while maintaining typical growth performance.

Table 4. Effect of Saskatoon berry pomace inclusion on nutrient digestibility (on a DM basis) and digestible energy in grower pigs.

	Treatment			
Calculated nutrient digestibility (%)	**A**	**B**	**C**	**SE**
GE	75.68	73.13	73.12	1.48
DM	78.66	76.29	76.66	1.27
TDF	41.63	37.85	43.16	3.37
IDF	33.71	28.82	75.09	3.63
SDF	78.85	77.60	76.76	2.51
CP	78.92	74.33	75.09	1.08
Calculated digestibility (kcal/kg)				
DE	3160.55	3111.29	3180.29	59.82
DE (DM basis)	3413.67	3345.70	3420.39	64.04

Note: A = basal diet; B = basal+5% SBP; C = basal+10% SBP; GE = gross energy; DM = dry matter; TDF = total dietary fiber; IDF = insoluble dietary fiber; SDF = soluble dietary fiber; CP = crude protein; DE = digestible energy; SE = standard error.

The effects of SBP inclusion on nitrogen losses and partitioning are shown in Table 5. There was a significant difference in total nitrogen loss between Diets B and C, with a tendency for Diet B to have a higher total nitrogen loss percentage than Diet A (p= 0.09). There was a significant difference in fecal nitrogen loss between Diets B and A, and Diets C and A. There was a significant difference in urine nitrogen loss between Diets B and C, with a tendency for Diet A to have a higher nitrogen loss percentage than Diet C (p= 0.06).

Table 5. Effect of Saskatoon berry pomace inclusion on nitrogen loss and nitrogen partitioning in grower pigs.

	Treatment			
Nitrogen losses (%)	**A**	**B**	**C**	**SE**
Total nitrogen loss	43.93	50.34	41.50	2.53
Fecal nitrogen loss	21.08	25.67	24.91	1.08
Urine nitrogen loss	22.85	24.67	16.59	2.22

Note: A = basal diet; B = basal+5% SBP; C = basal+10% SBP; SE = standard error.

Total nitrogen loss and fecal nitrogen loss was increased in SBP supplemented treatments. It is speculated that the SBP was able to pass through the intestinal tract into the hindgut and be somewhat utilized by microbial organisms, creating more bacterial nitrogen excretion and repartitioned into the feces instead of urine in the form of urea. However, total nitrogen loss was significantly higher in pigs supplemented 5% SBP than those supplemented 10% and tended to be higher than the control. Coupled with the 10% addition of nutrients added to all diets indicated that there was no reduction in dietary protein provided and the slight fiber addition from the SBP was not able to efficiently mitigate nitrogen losses in Diet B.

But the SBP addition was significantly able to increase nitrogen loss in the feces, and in Diet C, urinary nitrogen loss was significantly reduced compared to the other treatment groups. This indicates that a 10% SBP into the diet allowed for more fiber and protein utilization by microbes in the gut and did slightly reduce total nitrogen loss and was able to significantly shift nitrogen excretion from urea for bacterial protein synthesis, with excess excreted into the feces. Regarding the environmental impact of nitrogen excretion as a result of pomace inclusion, diets would need be formulated to address this issue.

IMPLICATIONS

The analysis of SBP on fiber digestibility in grower pigs demonstrated potential to be an of-value feed additive when supplemented at 10% of the diet based on body weight in terms of improving fiber utilization and nitrogen partitioning without any presumable adverse effects on health or performance.

ACKNOWLEDGEMENTS

This study was completed with support from the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge the participation of the cooperating farm in this research project, as well as the strategic program funding provided to Prairie Swine Centre by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.