RESEARCH REPORT
ENVIRONMENT

Title: Evaluation of Emerging Technologies in Swine Manure Management **NPB # 02-097**

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Abstract: The study was designed to determine the performance and carcass characteristics of wean to finish pigs fed diets with different fermentable carbohydrate sources (inulin and sugar beet pulp). Six hundred and forty early weaned (17–d old, BW=5.7±0.11kg) pigs were housed in an environmentally controlled facility from wean to finish. The duration of the study was divided into five phases: 5.7 to 10; 10 to 20; 20 to 50; 50 to 90; 90 to 115kg BW. Pigs were blocked by initial body weight and allotted to four dietary treatments: (1) corn soybean meal control diet (CON); (2) CON diet supplemented with inulin in drinking water providing 2 to 3 $g \cdot d^{-1}$ inulin for each pig (INU); (3) ground sugar beet pulp with inclusion rate of 5%, 7%, 9%, 12% and 12% in Phases 1, 2, 3, 4 and 5, respectively (SBP); (4) CON diet supplemented with antibiotics (ASP250, Alpharma, Chicago, IL) 0.25% in Phases 1 through 3 and 0.0% in Phases 4 and 5. Blood samples were collected from six pigs per treatment in Phases 3 through 5 and analyzed for plasma urea nitrogen (PUN) and plasma insulin-like growth factor-I (IGF-I). Nutrient digestibilities were measured with eight animals per treatment during Phases 2 through 4. Chromic Oxide was used as an inert marker. In addition, fecal samples from six pigs per dietary treatment were collected at the end of Phases 3 and 4 for determination of prevalence of microorganisms.

Pigs in AB group grew faster ($P < 0.01$) and had higher feed intake ($P < 0.01$) than the other treatment groups in Phases 1 through 3. Gain to Feed ratio was negatively influenced ($P < 0.01$) by sugar beet pulp and inulin supplementation in Phase 1 and by SBP in Phase 2. Inulin supplementation in drinking water tended to improve ($P = 0.30$) growth rate during Phases 1 through 3 compared to the CON group. In Phase 4, increased growth rate was observed in pigs supplemented with inulin in water (1021, 1054, 1026, 1002 g/d for CON, INU, SBP and AB groups, respectively; s.e. = 9.79; $P < 0.01$). In Phase 5, there was no difference in growth performance among treatment groups. Nutrient digestibilities were measured during Phases 2 through 4. Organic matter and nitrogen digestibilities were lower ($P < 0.05$) during Phases 2 through 4, whereas phosphorus digestibility was higher ($P < 0.05$) during Phases 2 and 4 in SBP group. The concentration of PUN was lower ($P < 0.05$) for the SBP group than other treatment groups during Phases 3 through 5.

There was no dietary effect on IGF-I concentration. Supplementation of AB resulted in lower ($P < 0.01$) total aerobic and anaerobic bacteria and bifidobacteria in pig feces in Phase 3. Dietary treatments had no effect on prevalence of E. coli and lactobacillus. The withdrawal of AB and inulin supplementation in Phase 4 resulted in an increase ($P< 0.01$) in total aerobes and anaerobes. Lactobacillus was lower ($P < 0.01$) in the CON and INU groups compared to SBP and AB groups. There were no dietary effect on the prevalence of E. Coli and bifidobacteria in Phase 4. Post-slaughter carcass characteristics, including average fat depth, average loin depth, lean percentage and carcass grade premium, were not influenced by the dietary treatments except dressing percentage, which was lower for the SBP group (74.4%, 74.4%, 73.4% and 74.6% for CON, INU, SBP and AB, respectively; s.e. =0.29; P=0.02).

In conclusion, supplementation of inulin in water improved pig performance during the late growth stage. Sugar beet pulp supplementation reduced nitrogen but increased phosphorus digestibility. Antibiotic supplementation reduced the prevalence of anaerobes and aerobes in pig feces. Carcass dressing percentage was reduced by SBP supplementation.

Introduction: A significant part of the dietary carbohydrates fraction escapes enzymatic digestion and is therefore a potential substrate for the gastrointestinal microflora. These carbohydrates include non-digestible oligosaccharides (NDOs). NDOs are found in several feedstuffs such as soybeans, lupins, peas, Jerusalem artichoke, sugar beet and chicory pulp. Fructooligosaccharides (FOS) are found in most cereals, including barley, wheat and in sugar beet and chicory pulp (Henry and Saini, 1989). FOS is a series of β-linked fructose units to the fructose moiety of sucrose and has been shown to improve growth performance in young pigs (Morimoto et al. 1984). These NDOs may be regarded as prebiotics, defined as “non-digestible feed ingredients that beneficially affect the host by selectively stimulating the growth and /or activity of one or a limited number of bacteria in the colon, and thus improve health”. Supplementing diets with NDOs increases the densities of lactic acid producing bacteria and provides numerous health benefits. These include enhanced enteric and systemic immune functions, increased energy and nutrient availability, inhibition of pathogen growth, reduced risk of carcinogenesis and improve levels and profiles of serum lipids.

In addition, FOS can be utilized by *Bifidobacterium spp*., *Bacteroides fragilis*, *Peptostreptococcus spp*., and *Klebsiellae*. However, FOS can not be utilized by *Escherichia coli* and several *Clostridium spp*. (Hidaka et al., 1986). Research has shown that that consumption of FOS by mice and baby pigs increased *Bifidobacterium spp*., (Howard et al., 1995) and reduced fecal and urinary excretion of the aromatic amino acids metabolites such as phenol and p-cresol by suppression of growth of *Escherichia coli* and *Clostridium spp.* (Hidaka et al., 1986). In addition to malodors, putrefactive products, like p-cresol, have been associated with depressed growth of swine (Yokoyama et al., 1982). An additional benefit to odor reduction, therefore, by supplementing a source of FOS such as chicory pulp and inulin in swine diets, may be the improved health and performance.

Objectives:
Determine the:

1. Effect of two sources of fermentable carbohydrates (inulin from Chicory pulp and sugar beet pulp) on performance of pigs fed antibiotics-free diet.

2. Effect of separation of manure solids from liquids on the movement of antibiotics, pathogens and phytase activity in the environment**.**

3. Fate and transport of pathogens in air, manure, run-off water, and soil as influenced by a source of fructo-oligosaccharides and anti-biotics in swine feed.

4. Effect of phytase in swine feed on phytase activity in manure and in the soils receiving the manure, and any resulting changes in the nature of P in soils and in the risk of loss of P in runoff from soils receiving manure.

Procedures:

All procedures were consistent with the Guide for the Care and the Use of Agricultural Animals in Agricultural Research and Teaching (FASS 1999) and were evaluated by the University of Minnesota Institutional Animal Care and Use Committee.

Growth performance and carcass characteristics data collection

Six hundred and forty early-weaned (17–d old, 5.7±0.11kg BW) pigs were housed in an environmentally controlled facility from wean to finish. There were four rooms with 16 pens per room and 10 pigs per pen. Pigs were blocked by initial body weight and allotted to four dietary treatments (Table 1): (1) corn soybean meal control diet (CON); (2) CON diet supplemented with inulin in drinking water providing 2 to 3 $g \cdot d^{-1}$ inulin for each pig (INU); (3) ground sugar beet pulp with inclusion rate of 5%, 7%, 9%, 12% and 12% in Phases 1, 2, 3, 4 and 5, respectively (SBP); (4) CON diet supplemented with antibiotics (ASP250, Alpharma, Chicago, IL) 0.25% in Phases 1 through 3 and 0.0% in Phases 4 and 5. The duration of the study was divided into five phases: 5.7 to 10; 10 to 20; 20 to 50; 50 to 90; 90 to 115kg BW. Pigs had access to feed and water always. The pig's weight and feed intake were recorded at end of each Phase for calculating the average daily gain (ADG), average daily feed intake (ADFI) and gain/feed (G/F). Post-slaughter carcass characteristics (fat depth, loin depth, lean percentage and carcass grade premium) were determined with 38 pigs per dietary treatment.

Measurements of fecal nutrient digestibilities

During Phases 2, 3 and 4, eight pigs per treatment with similar body weight were selected for total tract digestibility measurements. Chromic oxide (Cr_2O_3) was added to the diets at 2.0g/kg as an indigestible marker to determine the apparent fecal digestibility (AFD) of dry matter, nitrogen and phosphorus digestibilities. After a 7-d adjustment to, fecal samples were collected from each animal by anal stimulation, twice a day for 2 continuous days. Samples were pooled and sub-sampled and stored at –20°C in plastic bags. Fecal samples were thawed, one portion of which was used for analyzing nitrogen by the Kjeldahl method (AOAC, 1990) with an N2000 Nitrogen Analyzer (Foss, Sweden). The remaining feces were dried at 105°C to determine dry matter content. The feed and fecal samples were ground through a 1mm screen, and duplicate samples were prepared and analyzed for total P. Total P was determined colorimetrically by the vanadomolybdate procedure (AOAC, 1990). Chromic oxide in feed and feces were measured by the spectrophotometric method as described by (Fenton and Fenton, 1979).

Blood measurements:

During Phase 3 through 5, 3 barrows and 3 gilts with similar body weight per treatment group were selected and blood samples collected from the jugular vein into lithium heparinized tubes. The tubes were centrifuged at 2,000 × g for 10 min at 5°C. Aliquots of plasma from each pig were stored at -20°C until analyzed for PUN and IGF-1.

Plasma urea nitrogen (PUN) concentration was determined by a standard kit (Procedure No. 535) from Sigma Diagnostics (St. Louis, MO., USA). Plasma insulin-like growth factor I (IGF-I) concentration was analyzed with radioimmunoassay method as described by Hathaway et al. (2003).

Bacterial enumeration:

Fecal samples from six pigs per dietary treatment were collected at the end of Phases 3 and 4 for determination of prevalence of microorganisms. Fecal samples were collected into glass containers, sealed, and put on ice until they were transported to the lab for enumeration of microbial populations. Fecal samples were assessed for populations of total aerobes, coliforms, lactobacilli (aerobically), total anaerobes, and bifidobacteria. A gram of mixed fecal content was blended in 9 ml of pre-reduced buffered peptone water dilution solution. Bacterial colony form unit (cfu) was enumerated by inoculating triplicate 100-mm plates of the respective media with .1mL of the appropriate dilutions. Three dilutions were plated for each medium. Plates were inverted and incubated aerobically or an-aerobically at 37°C.

Total aerobes were enumerated using plates of Schaedler agar media (Difco, Detroit, Michigan) after 24-h incubation at 37°C aerobically.

Coliforms were enumerated using plates of MacConkey media (Difco, Detroit, Michigan) after 24-h incubation at 37°C aerobically.

Aerobic lactobacilli were enumerated using plates of Rogosa media (Difco, Detroit, Michigan) after 72-h incubation at 37°C aerobically.

Total anaerobes were enumerated using plates of Reinforced Clostridial Agar (RCA, Oxiod, CM 151) after 96 h incubation in anaerobic environment created by AnaeroGen Compact system (Oxoid).

Bifidobacteria were also enumerated after 96 h incubation in anaerobic environment created by AnaeroGen Compact system (Oxoid). BIM-25 (Munoa and Pares, 1988) was used as selective media. The media was made by supplementing Reinforced Clostridial Agar (RCA, Oxiod, CM 151) with 20 mg L-1 nalidixic acid, 8.5 mg L-1 polymyxin B, 50 mg L-1 kanamyxin, 25 mg L-1 iodoacetic acid and 25 mg L-1 2,3,5-triphenyltetrazolium chloride.

Results:

Objective 1: **Effect of a source of fructo-oligosaccharides (inulin from Chicory pulp) and sugar beet pulp on performance of pigs fed anti-biotic free diet.**

Phase 1 (Table 2). The ADG of pigs in AB group was greater (289g, $P < 0.01$) than other groups (240g, 243g and 218g for CON, INU and SBP groups, respectively). The ADG for AB was 17.0%, 15.9% and 24.6% higher than the CON, INU and SBP treatment groups, respectively. The ADFI for AB group (405g) was higher ($P<0.01$) than other treatment groups (346, 374 and 347g for CON, INU and SBP, respectively). The antibiotics also improved ($P < 0.01$) the gain/feed by 0.72 compared to 0.64 and 0.64 from inulin and SBP diets, but not different from the CON group.

Phase 2 (Table 2). The ADG of pigs in AB group was greater (554g, $P < 0.01$) than other groups (489g, 505g and 476 for CON, INU and SBP groups, respectively). However, There were no differences among other dietary treatments. The ADG for AB was 11.7%, 8.8% and 14.1 higher than the CON, INU and SBP treatment groups, respectively. The ADFI (978g) for AB group was higher than other treatment groups (827, 849 and 872g for CON, INU and SBP, respectively). Pigs in SBP group had a lower ($P < 0.05$) G/F than CON and INU groups (0.55 vs 0.59 and 0.60), but not different from AB group (0.57).

Phase 3 (Table 2). The ADG of pigs in AB group was greater (891g, $P < 0.05$) than other groups (820g, 834g and 823g for CON, INU and SBP groups, respectively). However, There was no difference-s among other dietary treatments. The ADG for the AB group was 7.6%, 6.3% and 8.0% higher than CON, INU and SBP groups, respectively. The ADFI for AB group (2005g) was higher ($P< 0.05$) than other groups (1868g, 1906g and 1898g for CON, INU and SBP, respectively). There were no differences for gain/feed among dietary treatments ($P > 0.05$).

Combined data from phases 1 through 3 for the growth period 5.7 to 50 kg BW (Table 2), indicates that pigs in AB group grew faster (601, 613, 594 and 666 g/d for CON, INU, SBP and AB, respectively; s.e. =8.10; $P < 0.01$) and had higher feed intake (1244, 1276, 1273, 1368 g/d for CON, INU, SBP and AB, respectively; s.e. =18.30; $P < 0.01$). Gain to Feed (G/F) was negatively influenced by sugar beet pulp supplementation compared to other groups (0.48, 0.48, 0.46, 0.49 for CON, INU, SBP and AB, respectively; s.e. =0.0036; $P < 0.01$).

Phase 4 (Table 2). Dietary supplementation of antibiotics was withdrawn from the AB to conform to normal husbandry practices. Thus pigs in CON and AB groups were given the same dietary treatment. The ADG (1054g) of pigs in INU group was greater ($P <0.05$) than the ADG for other groups (1021g, 1026g and 1002g for CON, SBP and AB, respectively). The ADG for INU was 3.1%, 2.7% and 4.9% higher than CON, SBP and AB groups, respectively. The ADFI for INU (3025g) or SBP (3000g) groups was higher ($P < 0.05$) than AB group (2886g), but not different ($P >0.05$) from the CON group (2965g). Feed efficiency was not influenced by dietary treatments.

Phase 5 (Table 2). There were no differences ($P > 0.05$) for ADG, ADFI and G/F among the dietary treatments. Overall performance from wean to finish (5,7 to 115 kg) was not influenced by dietary treatments.

Carcass characteristics are shown in Table 3. Dietary treatments had effects (P = 0.02) on dressing percentage. The dressing percentage for pigs in SBP group was lower than other groups (73.4% vs 74.4~74.6%). Fat depth, lean percentage and score were different ($P < 0.01$) between genders. Barrows had a higher ($P < 0.01$) average back fat, lower lean percentage and carcass score than gilts.

Apparent fecal digestibilities (AFD) of DM in Phase 4, OM and N in Phases 2 to 4 were significantly decreased ($P < 0.05$) for SBP group compared to other groups (Table 3). AFD of OM for SBP was significantly lower ($P< 0.05$) than that for CON or INU group. However, AFD of P was significantly improved ($P < 0.05$) for SBP group in Phases 2 and 4 compared to other groups except that in Phase 2, comparison between SBP and CON was not significant ($P > 0.05$).

Plasma urea nitrogen (PUN) concentration was lower ($P < 0.05$) for SBP group than any other group from Phase 3 to Phase 5 (Figure 1). PUN was higher ($P < 0.05$) in Phase 4 than in Phase 3. There was no significant interaction between treatments and phases ($P > 0.05$).

There was dietary treatment effect on plasma IGF-I concentration in phases 3 to 5 (Figure 2). SBP pigs maintained a relative constant IGF-I concentration throughout the

phases. An erratic change in IGF-I concentration was observed for INU pigs. Compared to Phases 3 or 5, INU pigs had a numerically lower IGF-I concentration in Phase 4. A decrease in IGF-I concentration was observed for the AB group when AB was withdrawn from the diet.

Table 1. Dietary composition (%) (as-fed basis) [a]

	Phase 1		Phase 2		Phase 3		Phase 4		Phase 5	
	CON	**SBP**	**CON**	**SBP**	**CON**	**SBP**	**CON**	**SBP**	**CON**	**SBP**
Item										
Corn	53.61	48.71	64.92	58.10	73.81	63.33	79.96	67.55	81.87	69.65
Soybean meal	27.00	27.00	28.32	28.23	21.38	22.38	17.27	17.37	15.66	15.56
Dried whey	10.00	10.00	1.00	1.00	-	-	-	-	-	-
Fish meal	4.00	4.00	3.00	3.00	1.50	1.50	-	-	-	-
SDPP	2.74	2.74	-	-	-	-	-	-	-	-
SBP	-	5.00	-	7.00	-	9.00	-	12.00	-	12.00
Limestone	0.83	0.73	0.70	0.53	0.82	0.59	0.78	0.48	0.77	0.47
Dicalcium phosphate	0.55	0.55	0.76	0.83	0.60	0.68	0.62	0.73	0.43	0.55
Blended animal fat	0.50	0.50	0.50	0.50	1.00	1.67	0.50	1.00	0.50	1.00
Salt	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Vit-Min Premix[b]	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
L-lysine·HCl	-	-	0.03	0.04	0.12	0.08	0.10	0.09	-	-
DL-methionine	-	-	-	-	-	-	-	0.01	-	-
Total	100	100	100	100	100	100	100	100	100	100
Determined analyses										
DM, % [d]	90.3	90.5	88.2	88.3	88.1	88.4	87.2	87.5	86.3	86.6
ME, kcal/kg[c]	3327	3303	3346	3306	3375	3360	3358	3319	3368	3329
Ca, %[c]	0.81	0.81	0.70	0.70	0.60	0.60	0.50	0.50	0.50	0.50
Avail. P, %[c]	0.42	0.41	0.34	0.35	0.25	0.26	0.21	0.23	0.17	0.19
Total P, %[d]	0.65	0.64	0.61	0.63	0.52	0.53	0.46	0.46	0.40	0.38
CP, % [d]	21.40	22.10	19.70	19.30	16.40	16.50	13.70	13.50	13.30	12.80
Lysine, %[c]	1.37	1.37	1.15	1.15	0.85	0.85	0.68	0.68	0.56	0.57
Methionine[c]	0.36	0.36	0.34	0.33	0.25	0.25	0.21	0.22	0.21	0.20
Threonine[c]	0.93	0.92	0.78	0.77	0.52	0.53	0.44	0.43	0.42	0.41
Tryptophan[c]	0.27	0.28	0.24	0.24	0.15	0.16	0.13	0.13	0.12	0.12
ISF, % [d]	9.24	11.40	10.10	13.50	10.00	13.80	9.85	14.00	10.70	14.90
SF, % [d]	0.51	1.68	0.83	2.43	0.50	2.57	0.40	3.47	0.38	3.34

[a] Abbreviations used: CON, control diet; SBP, sugar beet pulp supplemented diet; DBP, ground dried beet pulp; SDPP, spray dried porcine plasma; ISF: insoluble fiber; SF, soluble fiber.

[b] Premix supplied the following per kg of diet: Zn, 120 mg; Mn, 12 mg; Fe, 150 mg; Cu, 12 mg; Se, 1 mg; vitamin A, 5,000 IU; Vitamin D_3, 500 IU; vitamin E, 22 IU;

riboflavin, 12 IU; nicacin 45mg; calcium pantothenate, 24 mg; choline chloride, 840 mg; vitamin $B_{12,}$ 30 μg; biotin, 200 μg.

[c] calculated values.

[d] analyzed values.

Table 2: Effect of inclusion of inulin, sugar beet pulp and antibiotics on the performance of wean to finish pigs. [1]

Criteria	CON	INU	SBP	AB	SEM	Pvalue
Phase 1						
Initial WT (kg)	5.7	5.7	5.7	5.7	0.11	0.99
Final WT (kg)	9.4	9.5	9.0	10.2	0.20	<0.01
ADFI ($g \cdot d^{-1}$)	347^{a}	374^{a}	347^{a}	405^{b}	10.1	<0.01
ADG ($g \cdot d^{-1}$)	240^{ab}	243^{a}	218^{a}	289^{c}	8.2	<0.01
Gain:Feed	0.691^{a}	0.647^{b}	0.640^{b}	0.715^{a}	0.01	<0.01
Phase 2						
Initial WT (kg)	9.4	9.5	9.0	10.2	0.20	<0.01
Final WT (kg)	19.7	20.0	19.0	21.8	0.38	<0.01
ADFI ($g \cdot d^{-1}$)	827^{a}	849^{a}	872^{a}	978^{b}	20.7	<0.01
ADG ($g \cdot d^{-1}$)	489^{a}	505^{a}	476^{a}	554^{b}	10.4	<0.01
Gain:Feed	0.592^{a}	0.598^{a}	0.547^{b}	0.568^{ab}	0.01	<0.01
Phase 3						
Initial WT (kg)	19.7	20.0	19.0	21.8	0.38	<0.01
Final WT (kg)	49.8	50.6	49.3	54.4	0.67	<0.01
ADFI ($g \cdot d^{-1}$)	$1,868^{a}$	$1,906^{a}$	$1,898^{a}$	$2,005^{b}$	28.0	<0.01
ADG ($g \cdot d^{-1}$)	820^{a}	834^{a}	823^{a}	891^{b}	9.5	<0.01
Gain:Feed	0.440	0.439	0.435	0.445	0.004	0.05
Phase 1 through 3						
Initial WT (kg)	5.7	5.7	5.7	5.7	0.11	0.998
Final WT (kg)	49.8	50.6	49.3	54.4	0.67	<0.01
ADFI ($g \cdot d^{-1}$)	1,244b	1,277b	1,273b	1,369c	18.4	<0.01
ADG ($g \cdot d^{-1}$)	601b	613b	594b	666c	8.1	<0.01
Gain:Feed	483b	482b	468c	487b	4.0	<0.01
Phase 4						
Initial WT (kg)	49.8	50.6	49.3	54.4	0.67	<0.01
Final WT (kg)	89.8	91.7	89.4	93.5	0.90	<0.01
ADFI ($g \cdot d^{-1}$)	2965^{ab}	3025^{a}	3000^{a}	2886^{b}	34.8	0.04
ADG ($g \cdot d^{-1}$)	1021^{a}	1054^{b}	1026^{a}	1002^{a}	9.8	<0.01
Gain:Feed	0.345	0.349	0.342	0.348	0.003	0.41
Phase 5						
Initial WT (kg)	89.8	91.7	89.4	93.5	0.90	<0.01
Final WT (kg)	113.7	115.6	113.0	117.2	1.63	0.27
ADFI ($g \cdot d^{-1}$)	3425	3579	3503	3536	51.7	0.22
ADG ($g \cdot d^{-1}$)	1018	1043	1001	1015	19.3	0.49
Gain:Feed	0.297	0.292	0.286	0.287	0.005	0.38
Overall						
Initial WT (kg)	5.7	5.7	5.7	5.7	0.11	0.99
Final WT (kg)	113.7	115.6	113.0	117.2	1.63	0.27
ADFI (g·d-1)	2138	2222	2176	2216	34.7	0.30
ADG (g·d-1)	793	817	791	826	11.5	0.10
Gain:Feed	371	368	364	373	3.3	0.28

[1]Means within a row without a common superscript letter differ.

Table 3. Carcass characteristics for the pigs from the four dietary treatment groups.

	Fat Depth, cm	Muscle Depth, cm	Lean %	Dressing %	Score
CON	2.12	7.03	54.8	74.4a	7.1
INU	2.08	7.13	55.0	74.4a	7.3
SBP	1.92	7.01	55.2	73.4b	7.3
AB	2.00	7.06	55.1	74.6	7.7
s.e.	0.072	0.082	0.23	0.30a	0.25
Gilts	1.91a	7.11	55.4a	74.3	7.8a
Barrows	2.14b	7.01	54.6b	74.1	6.9b
s.e.	0.050	0.057	0.16	0.21	0.17
P(Treatments)	0.2	0.71	0.51	0.02	0.62
P(Gender)	<0.01	0.21	<0.01	0.47	<0.01
P(T×G)	0.62	0.98	0.79	0.43	0.35

Table 4. Effect of dietary treatments on the apparent total tract digestibility of DM, OM, N and P

	Diet					
Item	CON	INU	SBP	AB	SEM	*P* values
DM, %						
Phase 2	94.5	94.0	93.3	93.9	0.54	0.44
Phase 3	93.3	93.8	93.3	93.9	0.51	0.77
Phase 4	94.0[a]	93.9[a]	91.6[b]	93.7[a]	0.42	<0.01
OM, %						
Phase 2	83.9[a]	81.8[a]	76.2[b]	80.9[ab]	1.67	0.02
Phase 3	83.0[a]	81.7[a]	77.9[b]	82.8[a]	1.26	0.02
Phase 4	83.4[a]	82.2[a]	75.8[b]	82.4[a]	1.13	<0.01
N, %						
Phase 2	74.0[a]	73.2[a]	68.0[b]	73.2[a]	1.59	0.03
Phase 3	73.1[a]	73.2[a]	66.2[b]	77.3[a]	1.58	<0.01
Phase 4	74.7[a]	71.3[a]	65.1[b]	71.9[a]	1.44	<0.01
P, %						
Phase 2	47.8[ab]	44.5[b]	51.5[a]	47.0[b]	1.51	0.01
Phase 3	42.5	46.1	45.2	46.8	1.94	0.51
Phase 4	37.3[a]	40.2[a]	46.6[b]	39[a]	1.86	0.02

[ab] means with different superscripts within rows are different (*P*<0.05)

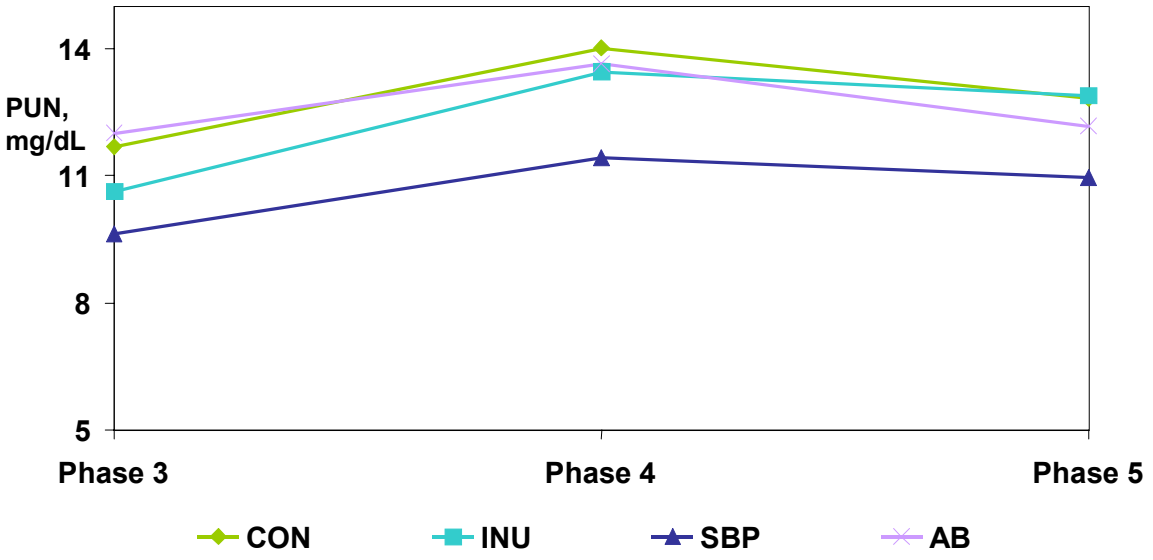

Figure 1. Effect of dietary treatments on plasma urea nitrogen (PUN) concentration during Phases 3, 4 and 5. Treatment effect, $P = 0.03$, s.e. = 0.48; phase effect, $P<0.01$, s.e. = 0.41.

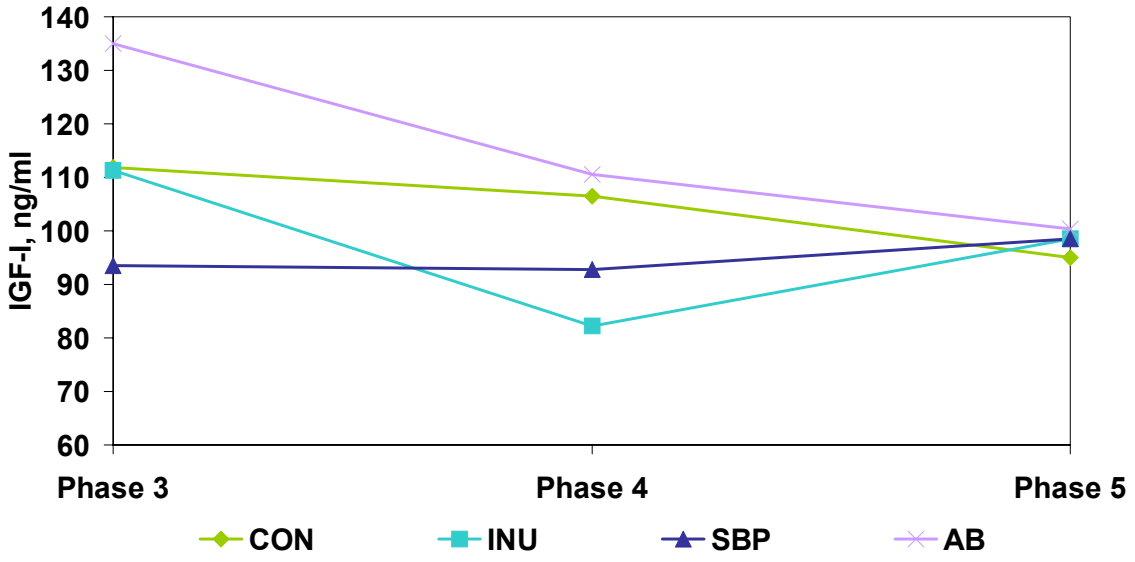

Figure 2. Effect of dietary treatments on plasma IGF-I concentration during Phases 3, 4 and 5. Treatment effect, $P = 0.29$, s.e. = 4.47; phase effect, $P = 0.01$, s.e. = 3.87; treatment×phase, $P= 0.14$, s.e. = 7.74

Objective 2: Effect of separation of manure solids from liquids on the movement of antibiotics, pathogens and phytase activity in the environment**.**

2. Digestive Study

Twelve pigs weighing 34.9 ±1.5 were raised individually in metabolism crates for 12 days, including 7 d acclimation and 5 d sample collection period. Three dietary treatments (Table 5) were randomly applied to each animal with 4 animals on each treatment. A plastic bag was attached to each pig with Velcro and medical glue. Approximately 2 kg feed was supplied for each animal. During sample collection days, total feces were collected in the plastic bags, pooled by animals and approximately 10% of the collection was sampled and stored at -20°C for future analysis.

Table 5. Experimental dietary composition and nutrient levels [a]

Ingredients	CON	CON+0.5% inulin	CON + 0.25% AB
Corn Meal	65.99	65.49	65.74
Soybean Meal	28.4	28.4	28.4
Fish Meal	3.0	3.0	3.0
Lime Stone	0.68	0.68	0.68
Dicalcium Phosphate	0.66	0.66	0.66
Salt	0.37	0.37	0.37
Vit-Min Premix	0.25	0.25	0.25
Choline	0.15	0.15	0.15
Antibiotic	-	-	0.25
Inulin	-	0.50	-
Tallow	0.5	0.5	0.5
Nutrient levels			
ME, Kcal/kg [c]	3357	3341	3348
Crude protein, %[b]	19.9	19.8	19.9
Lysine, %[c]	1.12	1.12	1.12
Ca, %[c]	0.66	0.66	0.66
Total P, %[b]	0.55	0.54	0.55

[a] as-is basis.
[b] determined values.
[c] calculated values.

Results: There were no effects on daily feed intake, daily nitrogen intake due to dietary treatments. However, 0.5% inulin or 0.25% AB in feed tend to result in less nitrogen excretion per unit of feed intake (P=0.09), and daily nitrogen retention for pigs fed inulin

or AB supplemented feed tend to be higher than control diet (P=0.05). There is no effect of dietary supplementation of inulin or AB on phosphorous intake, P excretion percentage or P retention (Table 9).

Table 4. Effect of inulin and AB supplementation on nitrogen and phosphorus balance

Parameters	CON	CON+0.5%inulin	CON+AB	s.e.	P value
Feed intake (g/d)	2077.4	2152.0	2047.0	55.2	0.42
N intake (g/d)	66.6	69.0	65.6	1.77	0.42
N excretion/intake, %	49.6	46.4	44.3	1.52	0.09
N retention, g/d[1]	33.6[b]	36.9[a]	36.5[a]	0.90	0.05
Fecal N: urine N	3.2	2.7	3.0	0.30	0.52
App. fecal N digestibility, %	87.8	87.2	89.0	1.08	0.50
P intake (g/d)	11.5	11.9	11.3	0.30	0.42
P excretion/intake, %	42.6	46.3	37.1	6.39	0.61
P retention, g/d	6.6	6.3	7.1	0.69	0.70

[1] Means with different letters in a row are significantly different.

Objective 3: Fate and transport of pathogens in air, manure, run-off water, and soil as influenced by a source of fructo-oligosaccharides and anti-biotics in swine feed.

No antibiotic residues were detected in manure or water samples. The anti-biotics (ASP250) was included in Phases 1 to 3 at 0.25%. We did not analyze for pathogens in air and soil. We did analyze microorganisms in feces in Phase 3 and 4.

Supplementation of AB resulted in lower ($P < 0.01$) total aerobic and anaerobic bacteria and bifidobacteria in pig feces in Phase 3 (Table 5). Dietary treatments had no effect on prevalence of E. coli and lactobacillus. The withdrawal of AB and inulin supplementation in Phase 4 resulted in an increase ($P < 0.01$) in total aerobes and anaerobes. Lactobacillus was lower ($P < 0.01$) in the CON and INU groups compared to SBP and AB groups. There were no dietary effects on the prevalence of E. Coli and bifidobacteria in Phase 4.

Table 5: Prevalence of microorganisms (log_{10} cfu/ g fresh weight contents) in feces of pigs [1]

Criteria	Dietary Treatments					
Phase 3	CON	INU	SBP	AB	SEM	P-value
Total aerobes	10.30a	10.40a	10.06a	9.35b	0.10	<0.01
Escherichia coli	5.23	5.35	5.02	5.90	0.23	0.09
Lactobacillus	9.53	9.54	9.34	9.34	0.05	0.12
Total anaerobes	10.31a	10.50a	10.21a	9.49b	0.16	<0.01
Bifidobacteria	9.96a	9.71a	9.64a	8.73b	0.19	<0.01
Phase 4						
Total aerobes	7.67a	8.40b	7.82a	8.53b	0.13	<0.01
Escherichia coli	3.11	3.34	3.03	3.26	0.15	0.12
Lactobacillus	6.82a	6.97ab	7.73c	7.45bc	0.18	<0.01
Total anaerobes	7.52b	7.91ab	7.61b	8.37a	0.17	0.01
Bifidobacteria	7.07	7.05	7.15	7.15	0.18	0.96

[1]Means within a row are different ($P < 0.05$) if superscripts differ

Objective 4: Effect of phytase in swine feed on phytase activity in manure and in the soils receiving the manure, and any resulting changes in the nature of P in soils and in the risk of loss of P in runoff from soils receiving manure.

Based on the recommendations by the Reviewers Scores Sheet, a request was made to omit the phytase portion of the study. Accordingly, the phytase portion of the study was omitted. The study was performed with four dietary treatments (1. Control 2. Inulin 3. SBP 4. Antibiotic).

Disscussion: Lower ADFI and ADG were associated with antibiotic withdrawal in the AB group during the 50 to 80 kg growth phase. This decline could be due to a possible unfavorable change in microflora in the pigs gastrointestinal tract (GIT). This change in microflora is reflected in the prevalence of total anaerobes and aerobes in phases 3 and 4.

Inclusion of sugar beet pulp increased insoluble fiber (INSF) by 24 - 39% from phases 1 to 5. This increased the INSF by 2 to 8 times in the SBP diet compared to the CON diet during phases 1 to 5. Pigs on SBP had slightly higher feed intake than pigs on CON during phases 2 to 5. Addition of SBP caused a poor growth rate in phase 1. Increase in fiber reduces digestion of protein, amino acids and minerals. Fiber also increases the rate of gut emptying due to its water-holding capacity. During early developmental stages, the GIT of piglets are not fully developed to accommodate the high fiber diet and thus impacts negatively on growth rate. As a result, lower ADG and feed efficiency were observed for pigs on SBP in phases 1 and 2. However, the growth rate of pigs on SBP were not different from the CON group from phase 3 to market weight of 115 kg BW. The benefits of fiber in swine feed includes improvement in intestinal morphology and structure, altering the intestinal microflora and a decrease in luminal concentration of ammonia. This is reflected in the reduction of PUN in pigs fed the SBP diet and consequent reduction in fecal nitrogen. However, because of the bulky nature of fiber, the carcass dressing percentage was reduced in pigs fed SBP. This could be due to the higher water holding capacity due to the fiber component of SBP. Growth promoting effect of dietary supplementation of inulin was observed in phase 4. This growth promoting effect may be due to its impact on the development of the GIT. Inulin has been suggested to have a direct and indirect (through the microflora and short chain fatty acid production) protective effect on the integrity of the mucosal structures.

Fecal concentrations of total , bifidobacteria and total anaerobes were reduced by antibiotic supplementation. From the results of this study, it appears that dietary supplementation of antibiotics affects bacteria populations generally because total aerobes and anaerobes, and lactobacillus were all increased after the antibiotic withdrawal.

In conclusion, antibiotic supplementation improved pig performance until it was withdrawn at about 50 kg BW. The usage of sugar beet pulp and inulin as a substitute for antibiotics did not provide the same performance as the group fed diets supplemented with antibiotics. However, in wean to finish situation, the overall performance of early weaned pigs to market weight of 115 kg BW will not require the supplementation of antibiotics according to our study.

Lay Interpretation:
Our findings in the project indicates that in a wean to finish system:

◊ Antibiotics may not be necessary for performance of pigs in a wean to finish system.

◊ Antibiotics modifies the micro-flora of the gastrointestinal tract by reducing total aerobes and an-aerobes.

◊ Sugar beet pulp can be used as substitute for antibiotics after the first two phases (5.7 to 20 kg BW).

◊ Inulin from chicory pulp can be used as an alternative to antibiotics from phases 1 to 5.

◊ Sugar beet pulp reduces dressing percentage but reduces back fat thickness and maintains lean yield.

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