Dietary factors do not influence the clinical expression of swine dysentery

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Summary

Three experiments were performed to determine the effect of manipulating the amount of fermentable substrates entering the large intestine on the incidence of swine dysentery after experimental infection with 1.8×10^{10} *Brachyspira hyodysenteriae* per day for 3 consecutive days. In Experiment One, diets were formulated to contain a high proportion of fermentable fiber (30% wheat shorts and 15% raw potato starch), or a high proportion of nonfermentable fiber (15% ground oat hulls), or a low proportion of fiber (corn-soybean meal diet). In Experiment Two, diets were formulated either with highly digestible parboiled rice and animal protein, which would provide little substrate for fermentation in the large intestine, or 25% beet pulp to provide a high content of fermentable fiber. A commercial barley-wheat soybean meal grower diet was used as the control. In Experiment Three, the experimental diet was formulated with highly digestible cooked rice and animal protein and the control diet was a commercial barley-wheat soybean meal grower diet. In all experiments, the diets failed to provide satisfactory protection against experimental infection with *B. hyodysenteriae*.

Keywords: swine, *Brachyspira hyodysenteriae*, diet, fermentable fiber

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Swine dysentery is a mucohemorrhagic colitis characterized by wasting and diarrheic feces that contain mucus, blood, and necrotic material.[1] The etiology is the spirochete *Brachyspira hyodysenteriae.* The disease causes economic loss due to pig mortality and severe depression in growth rates.[1] It is widely believed that the clinical expression of swine dysentery might be influenced by diet. Prohaszka, et al, observed that feeding a diet high in cellulose/hemicellulose prevented the clinical signs associated with infection with *B. hyodysenteriae*.[2] They suggested that by supplying more fermentable substrate to the colon, the diet increases volatile fatty acid (VFA) production, reducing colonic pH and creating an unfavorable environment for the spirochetes. In support of this hypothesis, anecdotal evidence indicates that control of spirochetal diarrhea (not swine dysentery) may be achieved by switching from a pelleted to a meal diet. This would increase the amount of resistant starch entering the cecum and colon, thereby increasing fermentation and VFA production.

In contrast to the above, it was recently reported that highly fermentable diets allowed swine dysentery to develop, but that highly digestible diets were protective.[3,4] These investigators have suggested that highly digestible diets limit the amount of substrate entering the cecum and colon and so reduce microbial fermentation and VFA production. Presumably, either limiting substrate or increasing colonic pH produces a protective effect. Further studies are clearly needed to clarify these contradictory results and to determine whether susceptibility to swine dysentery can be controlled nutritionally by feeding diets that lead to high or low fermentation in the large intestine.

Materials and methods

For Experiments One and Two, 24 barrows were obtained from the University of Alberta swine herd that were clinically free of swine dysentery and without clinical evidence of spirochetal colitis. For Experiment Three, 20 barrows were obtained from a commercial herd, also free of clinical swine dysentery and spirochetal colitis. Although no bacterial isolation was attempted to verify that the herds were free of *B. hyodystenteriae* and *B. pilosicoli*, there had never been a case of swine dysentery over the entire history of either herd used in these three experiments.

All experimental pigs were housed in groups of four in a temperature-controlled animal room (20–22°C, 68–72°F) and were fed ad libitum either a commercial grower diet or an experimental diet. Daily feed intakes were not calculated due to the nature of the experimental diets, which allowed considerable spillage onto the floor. Water was freely accessible from a low-pressure drinking nipple.

Inoculant

The spirochete suspensions were prepared by inoculating blood agar plates with the bacteria and then incubating the plates anaerobically for 48 hours. The bacteria were harvested from six plates and mixed in 21 mL sterile phosphate-buffered saline. One mL of the suspension was used for a viability count. There were approximately 3×10^8 CFU per mL of suspension.

Experiment One

Twelve pigs from the University of Alberta herd were assigned to one of three diets (Table 1):

- 2918 kcal per kg DE with a high proportion of fermentable fiber (30% wheat shorts and 15% raw potato starch; 10.7% neutral detergent fiber) in an attempt to simulate the high-fiber diet that Prohaszka and Lukacs[2] found to be protective against swine dysentery (n = 4);
- 3048 kcal per kg DE with a high proportion of nonfermentable fiber

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Table 1: Formulation and chemical composition of the experimental diets

Ingredient	Experiment One: high fermentable fiber	Experiment One: high nonfermentable fiber	Experiment One: low fiber	Experiment Two: low fiber, high digestiblity	Experiment Two: high fermentable	Control (Experiments Two and Three): commercial grower	Experiment Three: high digestibility cooked rice
Fish meal	-	-	-	9.0%	-	-	9.0%
Blood meal	-	-	-	4.0%	-	-	3.7%
Meat & bone meal	-	-	-	1.4%	-	-	6.9%
Soybean meal	24.7%	24.7%	24.7%	4.0%	19.0%	12.0%	4.0%
Wheat	-	-	-	-	49.6%	-	-
Wheat shorts	30.0%	-	-	-	-	-	-
Canola meal	-	-	-	-	-	6.0%	-
Corn	-	53.1%	53.2%	-	-	-	-
Oat hulls	-	15.0%	-	-	-	-	-
Hulless barley	-	-	-	-	-	76.4%	-
Potato starch	15.0%	-	-	-	-	-	-
Corn starch	23.4%	-	15.0%	-	-	-	-
Parboiled rice	-	-	-	78.3%	-	-	-
Cooked rice	-	-	-	-	-	-	73.8%
Canola oil	4.0%	4.0%	4.0%	-	3.0%	-	-
Tallow	-	-	-	-	-	2.0%	-
Beet pulp	-	-	-	-	25.0%	-	-
Sugar	-	-	-	-	-	-	0.05%
Lysine	-	-	-	-	-	0.25%	0.05%
Methione+ cysteine	-	-	-	0.09%	0.05%	-	-
Threonine	-	-	-	0.72%	0.16%	-	0.7%
Biophos	0.5%	0.9%	0.9%	-	1.7%	0.9%	1.0%
Calcium carbonate	1.1%	1.0%	1.0%	1.1%	-	-	-
Limestone	-	-	-	-	-	1.1%	0.05%
Vitamin-mineral premix	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Trace mineral salts	0.3%	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%
Chemical composition, as fed							
Crude protein	17.0%	16.5%	16.5%	17.8%	17.7%	19.6%	18.8%
DE, kcal/kg	2918	3048	3579	3485	3036	3402	3159
Lysine	1.0%	0.9%	0.9%	1.16%	0.94%	1.0%	1.3%
Methionine+ cysteine	0.55%	0.56%	0.56%	0.47%	0.58%	0.57%	0.84%
Neutral detergent fiber	10.7%	19.1%	7.3%	9.7%	18.25%	10.1%	10.0%

(15% ground oat hulls; 19.1% neutral detergent fiber) to serve as a control high fiber diet (n = 4); or

- 3579 kcal per kg DE with a low proportion of fiber (corn/heat-treated, solvent extracted, dehulled soybean meal diet; 7.3% neutral detergent fiber) (n = 4).

The diets for Experiment One were isonitrogenous (16.5%–17% crude protein) and were formulated with locally available ingredients.

After an 8-day adaptation period, pigs were fasted for 18 hours (Figure 1). Then, on each of 3 consecutive days, each pig was intragastrically inoculated via a stomach tube with 60 mL of the *B. hyodysenteriae* (B204) suspension (1.8×10^{10} spirochetes per day).

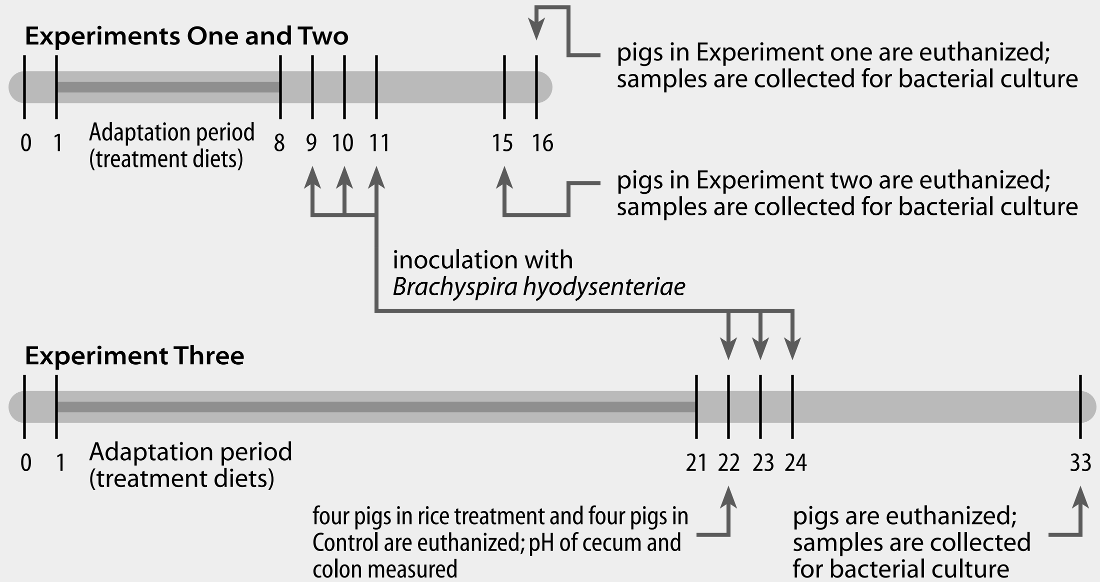
Pigs were euthanized at study day 16 and sections of distal ileum, cecum, proximal colon, middle colon, and distal colon were collected for reculture of spirochetes. No statistical analysis was performed on data.

Experiment Two

Rather than use conventional locally available ingredients, the experimental diets for Experiment Two were formulated to resemble as closely as possible those that have been previously reported to be protective against swine dysentery, and were compared to a commercial barley/soybean meal grower diet. Twelve pigs were assigned by weight to one of three diet treatments (Table 1):

- a low fiber-high digestibility diet, including 78% parboiled rice that provided 17.8% crude protein, 3435 kcal per kg DE, and 9.7% neutral detergent fiber (n = 4);
- a high fermentable fiber diet, including 25% beet pulp that provided 17.7% crude protein, 3036 kcal per kg DE, and 18.3% neutral detergent fiber (n = 4); or
- a control diet, which was a commercial barley/soybean meal grower diet,

Figure 1: Study timeline: Experiments One, Two, and Three



and provided 19.6% crude protein, 3402 kcal/kg DE, and 10.1% neutral detergent fiber (n = 4).

After an 8-day adaptation period, pigs were fasted for 18 hours (Figure 1). Then, on each of 3 consecutive days, each pig was intragastrically inoculated with 60 mL of the *B. hyodysenteriae* (B204) suspension (1.8×10^{10} spirochetes per day). Pigs were euthanized at study day 16 and sections of distal ileum, cecum, proximal colon, middle colon, and distal colon were collected for reculture of spirochetes. No statistical analysis was performed on data.

Experiment Three

Twenty pigs were assigned to one of two isonitrogenous diets (18.8%–19.6% crude protein; Table 1):

- a highly digestible experimental diet, formulated with 73.8% rice cooked in an oven until very soft, that supplied 3159 kcal per kg DE in order to closely approximate the protective diet described by Pluske, et al. (n = 10);[4] or
- a commercial barley/soybean meal grower diet (n = 10).

After a 21-day adaptation period followed by an 12- to 14-hour fast, four pigs from each dietary treatment were euthanized and the contents of the cecum, proximal colon, and distal colon were collected (Figure 1). The pH of these samples was determined within 5 minutes of death using a portable pH meter (Horiba Ltd.; Irvine, California). Where necessary, colonic content was liquefied in distilled water prior to insertion of the pH probe. Data for dietary effects on colonic pH were compared by a repeated-measures ANOVA using Number Cruncher Statistical System (Kaysville, UT).

The remaining pigs were intragastrically inoculated with 60 mL of the *B. hyodysenteriae* (B204) suspension (1.8×10^{10} spirochetes per day) on each of 3 consecutive days. Pigs were euthanized at study day 33 and sections of distal ileum, cecum, proximal colon, middle colon, and distal colon were collected for reculture of spirochetes.

Results

The average initial bodyweight of the pigs in all experiments was 20 kg (44 lb) (range 18–22 kg, 39.6–48.4 lb).

Experiment One

All pigs developed a mucohemorrhagic diarrhea within 16 days of inoculation. In this experiment, none of the diets provided protection to the pigs against dysentery.

Experiment Two

All pigs, except for one fed the parboiled rice diet, developed a mucohemorrhagic diarrhea within 15 days of inoculation. In this experiment, none of the diets provided protection to the pigs against swine dysentery.

Experiment Three

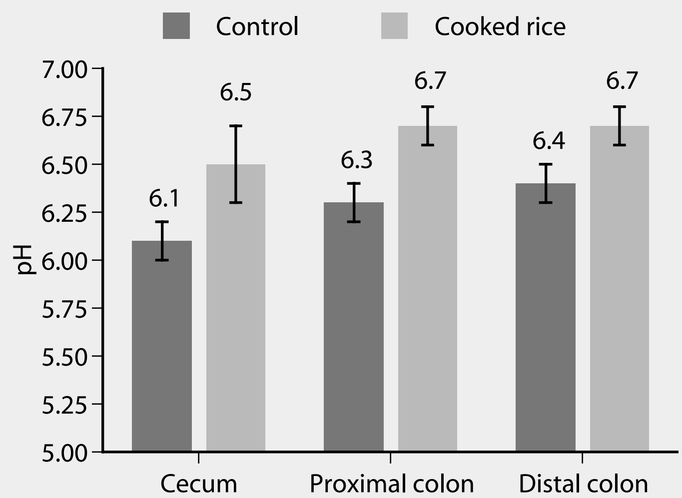
At the end of the 21-day adaptation period, the pH of colonic content (cecum and proximal and distal colon) was higher in the pigs fed cooked rice than in those fed the commercial grower diet ($P<.02$; Figure 2). All pigs except for two that received the commercial grower diet developed a mucohemorrhagic diarrhea within 7 days of inoculation. In this experiment, neither diet provided adequate protection to the pigs against swine dysentery.

Discussion

In the present study, the high fermentable-fiber diets did not reduce the incidence or severity of swine dysentery compared to control diets. The inconsistency of our results with those of Prohaszka and Lukacs[2] might be due to differences in the experimental design: their experiment was performed under noncontrolled field conditions on farms where a field strain of *B. hyodysenteriae* was endemic. In our experimental model, the pigs were fasted for 12–18 hours before inoculation on each of 3 consecutive days with a laboratory strain of *B. hyodysenteriae*. Under the conditions of the experimental model, when the bacteria entered the large intestine and proliferated, there may have been limited fermentable substrates available.

The results of Experiments Two and Three contrast with reports from Australia[3,4] since no protective effect was observed from feeding diets formulated with either

Figure 2: Mean (± SE) pH values of the content of cecum, proximal colon, and distal colon from pigs fed control or cooked rice based diets in Experiment Three



P < .02 for cooked rice diet

parboiled or cooked rice. The reason that we failed to obtain any dietary protection against swine dysentery is not known. The cecal and colonic pH in our cooked rice-fed pigs were similar to those observed by the Australian investigators, suggesting that the colonic response to the diets were not different. However, the pH values that result from fermentation of substances entering the large intestine may not be a precise measure of the relative favorability of the environment to spirochetes. Indeed, 95% of strains of *B. hyodysenteriae* can utilize most monosaccharides and produce acids with a pH of 6 and below.[5]

It is known that *B. hyodysenteriae* requires the presence of other bacteria before it can colonize the colonic mucosa.[6] It is possible that the resident flora in our pigs differed from that in the Australian pigs and so interacted differently with *B. hyodysenteriae*, resulting in a different clinical outcome.

Finally, we used a different strain of *B. hyodysenteriae* than did the Australian workers and our strain may respond differently to enteric environmental changes associated with the feeding of cooked rice.

In spite of previous work[2–4] and our observations, it is still unclear as to whether highly digestible or highly fermentable diets can protect pigs from infection by *B. hyodysenteriae*. Other experimental infection models need to be evaluated to eliminate the effect of feed withdrawal on the normal digestive and fermentation process in the intestine of pigs.

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