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EFFECT OF HIGHLY FERMENTABLE DIETARY FIBER ON PIG PERFORMANCE IN A LARGE UNIT, INFECTED WITH ENDEMIC SWINE DYSENTERY

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In a large south Hungarian fattening unit, 5637 pigs were allocated to 10 large barns and treated until slaughter as follows: Group 1 (n =2722): fed with diets containing 9.6 % highly fermentable neutral detergent fiber. Group 2 (n =2915): fed with diets containing 6.1 % poorly fermentable neutral detergent fiber.

In each group, the 200 smallest pigs were selected as test subjects (= 7.35% in group 1 and 6.86% in group 2). The animals were subjected to the following diagnostic procedures: fecal shedding of B. hyodysenteriae, antibody response, clinical signs, growth performance gross and microscopic lesions specific for swine dysentery (SD).

Seroconversion to and fecal shedding of B. hyodysenteriae were diagnosed in the majority of the pigs at day 30 after transport to the fattening unit. At necropsy, 187 animals in group one and all pigs in group two, revealed SD specific gross pathological lesions in the colon. All animals in both groups showed histological lesions of colon, typical for SD. The clinical impressions and diarrhea scores revealed significant differences ($p<0.05$) between the animals offered a diet with 9.6 % highly fermentable fiber and those fed on a diet with 6.1 % poorly fermentable fiber. Production parameters showed no significant differences, but mortality differed significantly between the two groups ($p<0.05$ - [4.07% in group 1 and 7.07% in group 2]).

Implications: highly fermentable neutral detergent fiber positively influences the clinical expression and productivity in fattening pigs, infected with endemic swine dysentery.

Key words: fattening unit, Brachyspira hyodysenteriae, swine dysentery, fiber, fermentable fiber.

INTRODUCTION

Swine dysentery (SD) is a mucohemorrhagic colitis, caused by *Brachyspira* (B.) *hyodysenteriae*. It affects pigs during the growing to finishing period and is characterized by wasting, low production performance and diarrheic feces that contain mucus, blood and necrotic material (Harris and Lysons, 1992). Mild colonic spirochetosis caused by *B. pilosicoli*, shows minor clinical signs of an enteric disease (Dufresne, 1998). SD causes economic losses due to pig mortality and

depression in growth rates (Prieksat, 2000). Environmental factors and postweaning problems with *E. coli* may influence the course of the disease (Roberts and Deen, 1995). Postweaning occurrence of SD may confuse the diagnosis and therapy of "postweaning coli complex" (PWCC), which is often complicated by concurrent infections with *Lawsonia intracellularis* (Bilkei *et al*., 1995).

The first evidence of the disease is soft yellow to gray feces. After a few hours or days following infection, large amounts of mucus, mucofibrinous or bloody shreds appear in the feces. Prolonged diarrhea leads to dehydration and increased thirst. The systemic effects of SD are due to the fluid and electrolyte imbalance induced by colitis (Harris and Lysons, 1992). The only significant histological lesions are found in the cecum and colon. Typical acute lesions include thickening of the mucosa and submucosa, vascular congestion, extravasation of fluids, hyperplasia of the goblet cells at the base of the crypts, excessive accumulation of neutrophils in and around capillaries near the lumen and superficial necrosis of the mucosa (Harris and Lysons, 1992). Chronic cases are not specific for SD and frequent secondary infections (with *Lawsonia intracellularis*, *Salmonella choleraesuis*, *E. coli*, *B. pilosicoli* or *Trichuris*) may be differentiated on the basis of bacteriological, serological or coprological examination (Bilkei *et al.*, 1995). In chronic and subclinical cases, careful monitoring of weight gain (average daily gain, ADG), may be the only clinical guide to the presence of the disease (Bilkei, 1996a). Moreover, some fattening animals can die showing only minor fecal abnormality and marked pallor (Harris and Lysons, 1992).

Clinical signs of SD seem to occur in a cyclic manner. In large groups of pigs affected with the disease, symptoms may appear and reappear at 3 to 4-week intervals (Bilkei, 1996a). Pigs that have recovered from SD may be asymptomatic, but shed *B. hyodysenteriae* in their feces (Songer and Harris, 1978). Clinical measurements and observations of gastrointestinal disorders should include statistical analysis (Bilkei, 1996a). Confirming the diagnosis of SD requires gross pathological and histological examination, serology and the isolation and identification of *B. hyodysenteriae* from the colonic mucosa or from feces (Waldmann and Plonait, 1997). Several serologic tests to detect antibodies to *B. hyodysenteriae* have been reported. They include macroscopic agglutination (Joens *et al*., 1978), enzyme - linked immunosorbent assay (ELISA) (Joens *et al*., 1981) and agar gel diffusion (Joens *et al.*, 1978). Hunter and Saunders (1977) used an absorbed antiserum in an indirect fluorescent antibody (IFA) test to detect *B. hyodysenteriae*. Lysons and Lemcke (1983) have presented evidence that questions the specificity of IFA tests. Egan *et al.* (1983) designed a method for determining the accuracy of serologic tests for SD as a means of determining the prevalence of the disease. Polymerase chain reaction (PCR) and IFA, are the suggested "up – to – date", diagnostic methods in practice (Waldmann and Plonait, 1997).

The treatment of SD includes the application of bacitracin, carbadox, gentamycin, lincomycin, tiamulin, tylosin and virginiamycin (Harris and Lysons, 1992).

The clinical expression of swine dysentery might be influenced by diet (Bilkei, 1996b). Before the advent of chemotherapeutics and antibiotics, SD was routinely treated by administering oats that had been soaked in salt water (Harris and Lysons, 1992). There is "anecdotal evidence" (Kirkwood *et al.*, 2000) that con-

trol of spirochetal diarrhea may be achieved by switching from a pelleted to a meal diet. Prohaszka and Lukacs (1984) observed that a cellulose / hemicellulose diet prevented the clinical signs associated with SD. In contrast to that Pluske *et al.* (1996) and Siba *et al*. (1996) found that highly fermentable diets allowed the development of swine dysentery, but highly digestible diets prevented it. In a recently published study (Baumann and Bilkei, 2002) after inoculation with a pure culture of 1.8 X 10^{10} *B. hyodysenteriae* pigs were fed either with diets containing either highly fermentable or poorly fermentable neutral detergent fiber. Significantly ($p<0.05$) milder clinical signs, typical for SD, were detected in animals fed with highly fermentable, compared to pigs fed with poorly fermentable fiber. Daily weight gain and food conversion efficiency were significantly ($p<0.05$) higher in the animals receiving highly fermentable fiber (Baumann and Bilkei, 2002).

The purpose of this field study was to evaluate the impact of different amounts and quality of neutral detergent fiber on the development of clinical signs and lesions of SD, using antemortal and postmortal diagnostic techniques.

MATERIAL AND METHODS

The present field trial was conducted on 5637 growing–fattening pigs of mixed sex and the same breed (F1 of Large White x Landrace), in a "specific pathogen free" (SPF) unit in Alföld in Hungary. The pigs in this herd were shown to be endemically infected with *B. hyodysenteriae* by serological testing (IFA), as well as tissue and feces PCR techniques.

The experimental pigs were weaned at day 28 of lactation, raised postweaning in a separate "flat – deck" room and ranged from 27-31 kg when transported to the fattening unit at 9–11 weeks of age. No antibiotics had been administered to these pigs in the nursery.

In the fattening unit the pigs were allocated to one of two groups (in 10 large fattening buildings, each with a capacity for 600 animals). The pigs were fed *ad libitum* from arrival to slaughter by the protocols given in tables 1 - 3. The buildings were totally confined and hygienically controlled single room facilities with 40 pens, separated by solid walls. The floor of the pens was 2/3 slatted concrete over a shallow pit. Stainless steel self - feeders and automatic nipple waterers serviced each pen. The pigs were weighed in groups (up to 15 animals per pen) on arrival and at slaughter. Feed disappearance was measured at weekly intervals.

Rectal swabs were taken on day 30 after arrival from the smallest looking pig in each pen (5 houses, 40 pens per house=200 pigs tested per group). The swabs were immediately laid on ice and sent to the laboratory of our consulting office. PCR reaction was used to detect *B. hyodysenteriae* from fecal swabs and defined as positive or negative. Blood samples were taken on day 30 after arrival from the smallest looking pig in each pen, to detect antibodies for *B. hyodysenteriae*, using IFA tests. The performer had no access to the codes used for samples. Each pen of pigs was observed daily for "diarrhea score" (DS) and "clinical impression score" (CIS) as described in table 4.

Table 1. Diet fed to pigs in a large fattening unit endemically infected with *Brachyspira hyodysenteriae:*

Group 1 (n = 2722)	offered diets with 9.6 % highly fermentable neutral detergent fiber (Mixing direction: 30% wheat shorts, 26.4% corn starch, 24%, soyabean meal, 12% raw potato starch, 4% sunflower oil, 3.6% mineral-vitamin-trace element mix).
Group 2 (n = 2915):	offered with commercial diets containing 6.1% poorly fermentable neutral detergent fiber (Mixing direction: 43% corn, 24% soyabean meal, 10.4% cooked rice, 15% corn starch, 4% sunflower oil, 3.6% mineral-vitamin-trace element mix).

Table 2. Amino acid patterns of the diets for pigs in relation to lysine

	Bodyweight (kg) dependant production period	
	25 - 60	late fattening
lysine	100	100
methionine + cystine	65	65
threonine	67	70
tryptophan	18	19
arginine	30	18
valine	68	68
isoleucine	60	60
leucine	100	100
phenylalanine + tryptophan	100	100
histidine	32	32

Table 3. Diet formula for growing fattening pigs from 25 -115 kg in two groups

Diet	Weight kg	Protein	Ly	Ca	Ph	G1/HFF %	G2/LFF %
1	25 – 40	15 – 16	0.9	0.66	0.67	9.6	6.1
2	41 – 60	13 – 14	0.8	0.65	0.55	9.6	6.1
3	61 – 115	13 – 14	0.8	0.64	0.54	9.6	6.1

Ly lysine
Ca calcium
Ph phosphorus
G group
HFF highly fermentable fiber
LFF commercial food with poorly fermentable fiber

Table 4. Diarrhea score (DS) and clinical impression score (CIS) used for pigs in a large fattening unit endemically infected with *Brachyspira hyodysenteriae*

Diarrhea score, DS
0 = no diarrhea 1 = semi – solid yellow to gray feces 2 = mucoid to mucopurulent feces , without bloody appearance 3 = blood - tingled mucopurulent feces 4 = blood - tingled mucopurulent to mucofibrinous feces
Clinical impression score, CIS
0 = normal 1 = occurrence of at least one pig in a pen showing the following clinical signs: depression, increased rectal temperature >40° C, arched back 2 = occurrence of at least one pig in a pen showing the following clinical signs: weaknees, uncoordination, emaciation

Table 5. Gross pathological colonic changes recorded in pigs endemically infected with *Brachyspira hyodysenteriae*

Pathological scoring of colon anatomy
1 = swelling and reddening of mucosa, colon contents of normal consistency 2 = mucosa covered by mucus and fibrin with flecks of blood 3 = thick mucofibrinous blood containing mucosal lesions 4 = marked superficial necrosis

The intestine of the smallest looking pigs in each pen were collected at slaughter. Sections of cecum and colon (proximal, middle and distal) were taken and gross pathological colonic changes were registered and scored as stated in table 5. Histological preparations (hematoxylin and eosin) of the colon were made and evaluated (table 6).

Table 6. Scoring of histological lesions of the colon in pigs endemically infected with *Brachyspira hyodysenteriae*

Histological scoring of the colon
0 = normal morphology 1 = thickening of the mucosa, superficial erosions with fibrinous pseudomembrane 2 = hyperplasia of the goblet cells at the base of the crypts, destruction of microvilli 3 = excessive accumulation of neutrophils in and around of capillaries near the lumen accompanied by superficial necrosis of the mucosa

The examined pig from each pen, was the experimental unit for statistical analysis for prevalence and severity of gross and histological lesions, fecal PCR

and IFA, DS and CIS. Average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FC) data were statistically analyzed (SAS; Cary, North Carolina, GLM procedure, 1990) using the pen as the experimental unit. Fischer's Exact Test was used to analyze gross pathological and histological data.

RESULTS

In each group, 200 pigs were tested (7.35% of the total in group one and 6.86% in group two). Of those tested, 187 pigs in group one and all 200 in group two had SD typical gross pathological lesions in their colon. All animals in both groups showed histological lesions of the colon typical for SD. Seroconversion to and fecal shedding of *B. hyodysenteriae* at day 30 after transport occurred in 181 and 180 pigs respectively in group one and in 184 and 182 animals respectively in group two (table 7).

Table 7. The results of different measurements and observations in pigs endemically infected with *Brachyspira hyodysenteriae* and fed with diets containing 9.6 % highly fermentable fiber (group 1) or 6.1 % (group 2) poorly fermentable neutral detergent fiber

	Group 1 n2722	Group 2 n2915
Number of pigs examined (%)	200 / 7.35%	200 / 6.86%
Gross colonic lesions (No)	187	200
Histological lesions of colon (No)	200	200
Seroconversion to B. hyodysenteriae at day 30 after transport into fattening unit (No)	181	184
Fecal shedding of B. hyodysenteriae at day 30 after transport into fattening unit (No)	180	182
Average group daily clinical impression score (CIS), (0 – 2)	9 **a**	17 **b**
Average group diarrhea score (DS), (0 – 4)	41 **a**	71 **b**
Pig initial weight kg (sd)	29.6(1.12)	30.1(1.08)
Pig final weight kg (sd)	113.3(2.01)	114.1(2.11)
Average daily gain, kg (ADG)	0.68	0.63
Average daily feed intake, kg (ADFI)	2.25	2.16
Food conversion efficiency (FC)	3.38	3.51
Mortality %	111 / 4.07% **a**	206 / 7.07% **b**

a b. Different letters in bold type indicate statistically significant differences between the groups ($p<0.05$).

Average group CIS and DS was significantly different ($p<0.05$) between the groups (table 7). Production parameters (ADG, ADFI, FC), were not significantly different between the groups. Mortality differed significantly, ($p<0.05$) between the animals fed with diets containing 9.6 % highly fermentable fiber and those fed with the commercial diet containing 6.1 % poorly fermentable neutral detergent fiber (111 / 4.07% in group one and 206 / 7.07% in group two) (table 7).

DISCUSSION

It is "widely believed" (Baumann and Bilkei, 2002) that the clinical expression of SD might be influenced by diet. Prohaszka and Lukacs (1984) reported that a more fermentable substrate increases volatile fatty acid production and reduces colonic pH, which creates an unfavorable environment for spirochetes. It has been noted (Bilkei *et al.*, 1995) that a high fiber containing diet decreases bacterial buildup in the colon. In contrast to this, Pluske *et al*. (1996) and Siba *et al*. (1996) found that highly digestible diets limit the amount of substrate entering the cecum and colon and reduce microbial fermentation and volatile acid production. Pluske *et al*. (1996) and Siba *et al.* (1996), speculated that highly digestible diets were protective against SD. Kirkwood *et al.* (2000) failed to provide protection against SD with different diet formulations.

Standardized diagnostic tools (tables 4, 5, 6) seem to be complicated at first sight. Nevertheless, in a scientific report, a standard clinical and gross pathological diagnostic system is necessary, in order to compare large numbers of individual animals objectively. Despite these arguments, we are aware that in practice, such standard diagnostic procedures are not always welcomed and their proper execution depends on the performers experience. In order to obtain objective results in the present trial, all clinical, gross pathological and histological tests were performed by the same person.

In this trial, a highly fermentable fiber–diet reduced the incidence and severity of SD compared to the control diet. These findings are consistent with the results of Prohaszka and Lukacs (1984) and Baumann and Bilkei (2002). The former authors also performed their trial under noncontrolled field conditions on farms where field strains of *B. hyodysenteriae* were endemic. In the study of Baumann and Bilkei (2002) the animals had been inoculated with *B. hyodysenteriae.* Therefore the results are difficult to compare with noncontrolled natural infections under field conditions. Kirkwood *et al.*, 2000, faund that highly fermentable diets did not reduce the incidence or severity of SD. In the first of three experiments the pigs were fed either a highly fermentable or a non fermentable fiber or low fiber diet. In contrast to the present trial, Kirkwood *et al.* (2000) found no differences in clinical expression of SD between the groups. In experiment two diets were formulated either with highly digestible parboiled rice or with highly fermentable fiber. The clinical expression of SD also showed no differences between the groups (Kirkwood *et al*., 2000). The same authors used diets formulated with highly digestible cooked rice in a third experiment. The control ration was a commercial barley – wheat – soybean meal grower diet. This experiment failed to provide satisfactory protection against experimental infection with *B. hyodysenteriae* as well. Unfortu-

nately no statistical analysis was performed on production data, clinical expression, or gross and histological lesions.

Smibert (1991) stated that 95% of *B. hyodysenteriae* strains can utilize highly digestible monosaccharides and produce acids with a pH of 6 or lower. In contrast to this, Pluske *et al.* (1996) and Siba *et al.* (1996) suggested that highly digestible diets result in higher colonic pH values (caused by reduced microbial fermentation and volatile fatty acid production). However, high pH values may not be favorable for spirochetes (Smibert, 1991). In contrast to other authors (Pluske *et al.*, 1996, Siba *et al*., 1996), no protective effect against SD was observed in the presented trial by feeding highly digestible diets.

The detection of *B. hyodysenteriae* carrying animals has been controversially discussed (Harris and Lysons, 1992). Serologic tests (such as ELISA) have limited sensitivity and can be used only on a herd basis and not to detect individual animals (Charette and Mittal, 1996). It has been suggested that serology can be combined with PCR diagnostic methods (Fellström *et al.*, 1996). Harris and Lysons (1992) stated that the IFA technique is a reliable serological test for detection of a *B. hyodysenteriae* infection. Nevertheless, there is some controversy about the value of the IFA technique (Egan *et al.*, 1983). The IFA antibody labeling technique, confirmed the presence of *B. hyodysenteriae* in the present trial. Although, there is skepticism about the value of PCR diagnosis of SD, it has been emphasized (besides culture and IFA) in German language literature (Waldmann and Plonait, 1997).

In summary, a diet containing a highly fermentable neutral detergent fiber positively influences the clinical expression of symptoms and mortality in fattening units infected with endemic swine dysentery.

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UTICAJ ISHRANE LAKO SVARLJIVIM VLAKNIMA NA PERFORMANSE SVINJA SA VELIKE FARME INFICIRANE ENDEMSKOM DIZENTERIJOM

BILIC B i BILKEI G

SADRŽAJ

Ova ispitivanja su izvršena na velikoj farmi svinja gde je 5637 tovljenika podeljeno na dve približno jednake grupe. Prva grupa je bila hranjena smešama koje su sadržavale lako svarljiva vlakna u koncentraciji od 9.6% dok je druga grupa dobijala hranu sa 6.1% vlakana niske svarljivosti. Iz svake grupe je izabrano po 200 jedinki kod kojih je dokazivano prisustvo B. hyodysenteriae, određivan imunski odgovor, registrovani klinički znaci i vršena patoanatomska i patohistološka ispitivanja. Naši rezultati ukazuju da je ishrana lako svarljivim vlaknima imala uticaja na smanjenje ispoljavanja kliničkih simptoma endemske dizenterije i smanjenje mortaliteta obolelih svinja.