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Effects of Fermented Potato Pulp on Performance, Nutrient Digestibility, Carcass Traits and Plasma Parameters of Growing-finishing Pigs

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ABSTRACT : A total of 629 Duroc×Landrace×Large White crossbred pigs were utilized in three experiments (Exp. 1, 222 pigs weighing 25.6±2.0 kg BW; Exp. 2, 216 pigs weighing 56.2±4.3 kg BW; Exp. 3, 191 pigs weighing 86.4±4.6 kg BW) conducted to determine the effects of fermented potato pulp on performance, nutrient digestibility, carcass traits and plasma parameters in growing-finishing pigs. Each experiment lasted 28 d. The pigs were assigned to one of two corn-soybean meal-based diets containing 0 or 5% fermented potato pulp. The inclusion of fermented potato pulp increased weight gain ($p<0.05$) in experiments 1 and 2 and increased feed intake ($p<0.05$) in experiment 2. Feed conversion was improved ($p<0.05$) in experiment 2 and showed a tendency to improve ($p<0.10$) in experiments 1 and 3 when pigs were fed fermented potato pulp. Fermented potato pulp increased ($p<0.05$) dry matter digestibility in experiments 1 and 3 and energy digestibility in experiment 2. Feeding fermented potato pulp decreased plasma urea nitrogen ($p<0.05$) and alanine aminotransferase ($p<0.05$) in experiments 1 and 2, while plasma aspartate aminotransferase was decreased ($p<0.05$) in experiment 3. Dietary fermented potato pulp did not affect the carcass characteristics of finishing pigs. Feeding fermented potato pulp reduced ($p<0.05$) fecal ammonia concentration in all three experiments. In conclusion, feeding growing-finishing pigs diets containing 5% fermented potato pulp improved weight gain and feed conversion without any detrimental effects on carcass traits. The improvements in pig performance appeared to be mediated by improvements in nutrient digestibility. (**Key Words :** Fermented Potato Pulp, Growing-finishing Pigs, Performance, Blood Parameters, Carcass Characteristics, Fecal Noxious Gas)

INTRODUCTION

Corn, soybean meal and wheat bran are the most common ingredients used in swine diets in China. They are used because of their high nutritional value and economic benefits (Ministry of Agriculture, 2004). However, as the size of the swine industry increases, the supply of these three raw materials will become more and more inadequate. Exploitation of new feed resources is an effective approach to resolve this issue.

Potato by-products represent an opportunity for livestock feeders because they are an inexpensive but energy-dense dietary ingredient (Szasz et al., 2005). More than 80 million tons of potatoes were produced in China in 2009 (National Bureau Statistics of China, 2010). Although less than 10% of these potatoes are processed in the potato starch industry, there would be nearly 5 million tons of potato pulp are generated each year (National Bureau Statistics of China, 2010).

Potato pulp contains starch, cellulose, hemicelluloses, pectin, proteins, free amino acids and salts (Mayer and Hillebrandt, 1997). Fermentation is an effective process whereby the starch and sugar in the potato pulp are transformed by microbes into fermentation products including lactic acid, volatile fatty acids and alcohol (Prescott et al., 1996). Feeding diets containing fermented liquid feed has been shown to increase pig performance and improve the environment in the gastrointestinal tract (Rijnen et al., 2001; Canibe and Jensen, 2003; Missotten et al., 2010).

Recent studies conducted in our laboratory indicated that feeding fermented potato pulp had a positive effect on the performance of lactating sows (Xue et al., 2011). However, there is little information regarding the use of fermented potato pulp in diets fed to growing-finishing pigs. Therefore, the present study was conducted to investigate

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the effects of feeding fermented potato pulp on performance, nutrient digestibility, carcass characteristics and fecal noxious gases in growing-finishing pigs.

MATERIALS AND METHODS

The experimental procedures used in these experiments were approved by the Institutional Animal Care and Use Committee of China Agricultural University (Beijing, China).

Fermented potato pulp

The fermented potato pulp used in this experiment was obtained from the Heilongjiang Songtian Potato Industry Corporation (Suihua, China). The process used to produce the product involved solid-state fermentation by anaerobic microbes. The liquid culture included *Streptococcus thermophilus* (CGMCC No. 1.2471), *Bacillus subtilis* (MA 193) and *Saccharomyces cerevisae* (CGMCC No. 2.1793). Fermentation was conducted for 4 days at 25°C. A chemical analysis of the product is shown in Table 1.

Animals and facilities

Three experiments were conducted at the Hebei Huailai Changfu Pig Culture Company (Hebei, China). All pigs (Duroc×Landrace×Large White) were housed in an all-in, all-out room in which the temperature was controlled between 17 and 22°C. The light schedule was 12 h of light and 12 h of dark. Pigs had free access to water and feed and all experimental diets were provided in mash form.

Experimental diets and measurements

For experiments 1 to 3, a total of 222, 216 and 191 crossbred pigs (Duroc×Landrace×Large White), weighing 25.6±2.0, 56.2±4.3 and 86.4±4.6 kg of BW were assigned to one of two corn-soybean meal-based diets containing either 0 or 5% fermented potato pulp (Table 2). The metabolizable energy (ME) content of all diets was 3.25 Mcal/kg and the ratios of lysine to ME were 3.2, 2.8 and 2.3 in experiments 1 to 3, respectively. These ratios were chosen based on the work of Beaulieu et al. (2009). Other amino acids were balanced relative to lysine using crystalline amino acids in order to match the ideal amino acid profile of NRC (1998). Due to the high moisture content of the fermented potato pulp, the experimental diets were never mixed more than two days before feeding in order to prevent mold development.

All three experiments used a complete randomized design and were conducted for 28 days. Each treatment was applied to six 3×4.5 m^2 pens containing 15 to 20 pigs. Wherever possible, equal numbers of barrows and gilts were housed in each pen. Each pen was equipped with a nipple waterer and two 2-hole dry feeders. Individual pigs and feeders were weighed at the beginning and the end of the experiment and these values were used to calculate weight gain, feed intake and feed conversion.

From day 26 to 28, approximately 50 g of feces was collected from each pen for three days and the fecal samples were stored at -20°C prior to being oven dried. The three day collection of feces was pooled by pen and then dried at 60°C for 72 h. All samples were ground to pass through a 1.0 mm screen (40 mesh) before analysis. Nutrient digestibility was determined using the indicator method described by Fan and Sauer (2002). The equation used was as follows:

$$ND\ (\%) = 1-[(DC\times FN)/(FC\times DN)]\times 100\%$$

Where, ND is the apparent total tract digestibility, DC is the content of Cr_2O_3 in the assay diet (%), FN is the content of a nutrient in the feces (%), FC is the content of Cr_2O_3 in the feces (%), DN is the content of a nutrient in the diet (%).

On the morning of day 28, blood samples were collected into 9 ml vacuum-filled, blood collection tubes coated with lithium heparin (Greiner Bio-One; GmbH, Kremsmünster, Austria). Samples were collected from the jugular vein of a randomly chosen pig in each pen. The samples were centrifuged at 3,500×*g*, for 5 min (Ciji 800 Model Centrifuge; Surgical Instrument Factory, Shanghai, China) and stored at -80°C until needed for further analysis.

At the end of experiment 3, one pig was selected randomly from each pen to be slaughtered to determine carcass characteristics (left side of each carcass). Hot carcass weight (dressing percentage = carcass/body weight), third or fourth rib, tenth rib and last rib back fat thickness as well as loin eye area (0.7×loin eye width×depth, cm^2) were measured. The pH of the carcass was measured with a pH meter (HI 8424NEW, HANNA, Rome, Italy) 45 min after

Table 1. Chemical composition of fermented potato pulp (as fed)

Item	Concentration
Metabolizable energy (Mcal/kg)[1]	2.08
Moisture (%)	35.20
Crude protein (%)	9.20
Lysine (%)	0.26
Methionine (%)	0.17
Threonine (%)	0.33
Tryptophan (%)	0.07
Crude fiber (%)	8.60
Ether extract (%)	1.90
Ash (%)	2.40
Calcium (%)	0.05
Phosphorus (%)	0.37

[1] The metabolizable energy content of fermented potato pulp was previously determined in growing-finishing pigs.

Table 2. Ingredient and chemical composition of experimental diets (% as-fed)

	Exp. 1 (25-45) kg Potato pulp (%)		Exp. 2 (56-78) kg Potato pulp (%)		Exp 3. (86-109 kg) Potato pulp (%)	
	0	5	0	5	0	5
Ingredient (%)						
Corn	65.75	61.15	70.75	66.15	68.75	64.05
Soybean meal	25.95	25.75	21.00	20.80	14.50	14.40
Wheat bran	4.00	3.80	4.00	3.80	10.46	10.26
Soybean oil	0.00	0.00	0.00	0.00	2.00	2.00
L-lysine·HCl	0.02	0.02	0.00	0.00	0.00	0.00
DL-methionine	0.03	0.03	0.00	0.00	0.01	0.01
L-threonine	0.00	0.00	0.00	0.00	0.02	0.02
L-tryptophan	0.00	0.00	0.00	0.00	0.01	0.01
Fermented potato pulp	0.00	5.00	0.00	5.00	0.00	5.00
Vitamin-mineral premix[1]	4.00	4.00	4.00	4.00	4.00	4.00
Chromic oxide	0.25	0.25	0.25	0.25	0.25	0.25
Analyzed composition (%)						
Crude protein	17.20	17.29	15.40	15.48	13.64	13.66
Lysine	1.05	1.04	0.91	0.92	0.76	0.77
Methionine	0.29	0.29	0.24	0.24	0.22	0.22
Threonine	0.71	0.71	0.62	0.62	0.54	0.54
Tryptophan	0.21	0.21	0.18	0.18	0.16	0.16
Calcium	0.82	0.82	0.81	0.81	0.79	0.79
Phosphorus	0.49	0.49	0.48	0.48	0.47	0.47

[1] Vitamin and mineral premix provided the following per kg of feed:

25-45 kg: vitamin A, 6,000 IU; vitamin D_3, 2,400 IU; vitamin E, 21.6 IU; vitamin K_3, 2 mg; vitamin B_1, 0.96 mg; vitamin B_2, 5.2 mg; vitamin B_6, 2 mg; vitamin B_{12}, 12 μg; nicotinic acid, 22 mg; pantothenic acid, 11.2 mg; folic acid, 0.4 mg; biotin, 40 μg; choline chloride, 0.4 g; Fe, 120 mg; Cu, 140 mg; Zn, 100 mg; Mn, 16 mg; I, 0.24 mg; Se, 0.4 mg; Ca, 7.2 g; P, 0.8 g; NaCl, 4.4 g.

56-78 kg: vitamin A, 5,600 IU; vitamin D_3, 2,200 IU; vitamin E, 21.6 IU; vitamin K_3, 1.8 mg; vitamin B_1, 0.88 mg; vitamin B_2, 4 mg; vitamin B_6, 1.8 mg; vitamin B_{12}, 12 μg; nicotinic acid, 20 mg; pantothenic acid, 10 mg; folic acid, 0.4 mg; biotin, 40 μg; choline chloride, 0.32 g; Fe, 88 mg; Cu, 120 mg; Zn, 96 mg; Mn, 16 mg; I, 0.24 mg; Se, 0.4 mg; Ca, 7.2 g; P, 0.8 g; NaCl, 4.4 g.

86-109 kg: vitamin A, 5,200 IU; vitamin D_3, 2,000 IU; vitamin E, 17.2 IU; vitamin K_3, 1.6 mg; vitamin B_1, 0.8 mg; vitamin B_2, 3.6 mg; vitamin B_6, 1.6 mg; vitamin B_{12}, 10 μg; nicotinic acid, 17.6 mg; pantothenic acid, 8.8 mg; folic acid, 0.38 mg; biotin, 32 μg; choline chloride, 0.24 g; Fe, 76 mg; Cu, 120 mg; Zn, 76 mg; Mn, 12 mg; I, 0.24 mg; Se, 0.4 mg; Ca, 7.2 g; P, 0.4 g; NaCl, 4.4 g.

slaughter and again 24 h after being placed in a 4°C refrigerator. Meat color was determined with a Chromameter, CR 400 (Minolta, Tokyo, Japan).

At the end of each experiment, fresh feces were collected from three randomly selected pigs in each pen to determine the fecal concentration of carbon dioxide and ammonia. A 100 ml-syringe was used to sample the air 2 cm above the fresh feces. A special test tube (Shanghai Yudong Electronic Science and Technology Ltd. Shanghai, China) was connected to the syringe and the air was gently pushed into the test tube over a 3 min period. The fecal concentrations of carbon dioxide and ammonia were read directly from the test tube. The methodology was similar to Wang et al. (2009).

Chemical analysis

Feed samples were collected at the beginning of each experiment and ground to pass through a 1.0-mm screen (40 mesh). Analyses for dry matter, calcium, and total phosphorus were conducted according to the methods of AOAC (1990). Gross energy was measured using an Automatic Adiabatic Oxygen Bomb Calorimeter (Parr 6300 Calorimeter, Moline, IL).

The amino acid concentration of the diets was analyzed after the diets were ground through a 60 mesh screen. Feed samples were hydrolyzed in 6 N HCl (10 ml) at 110°C for 24 h under nitrogen. Sulfur containing amino acids were measured after performic acid oxidation (AOAC, 1990). Trytophan content was determined colorimetrically after alkaline hydrolysis following the procedures described by Miller (1967). The amino acids were analyzed using a S-433D Amino Acid Analyzer (Sykam GmbH, Kleinostheim, Germany). Identification and quantification of amino acids were achieved by comparing the retention times of the peaks with those of standards.

The concentration of plasma urea nitrogen, alanine aminotransferase, aspartate aminotransferase, total cholesterol, low-density lipoprotein, high-density lipoprotein and creatinine was measured with an Automatic Biochemical Analyzer (RA-1000; Bayer Corporation, Tarrytown, NY) using colorimetric methods and the instructions from the manufacturer's reagent kit (Zhongsheng Biochemical Company, Beijing, China).

Statistical analysis

The pen was the experimental unit for all analyses. Data were analyzed using the *t*- test of SAS (SAS Inst. Inc., Cary, NC). Statistical significance was declared at p<0.05 and a trend was expressed when p<0.10. Results are presented as least square means.

RESULTS AND DISCUSSION

The effects of fermented potato pulp on the performance of pigs during the growing, early finishing and late finishing stages are shown in Table 3. Weight gain was significantly increased (p<0.05) for pigs fed the fermented potato pulp in experiments 1 (25-45 kg) and 2 (56-78 kg) while weight gain was unaltered in experiment 3 (86-109 kg). Fermented potato pulp increased feed intake (p<0.05) only in experiment 2 (56-78 kg). Feed conversion improved (p<0.05) in experiment 2 (56-78 kg) and showed a trend towards improvement (p<0.10) in experiments 1 (25-45 kg) and 3 (86-109 kg) when pigs were fed fermented potato pulp.

The use of fermented feed has previously been shown to improve livestock performance (Canibe et al., 2008; Hu et al., 2008; Chiang et al., 2010; Cho and Kim, 2011). Our results support these studies. The process of fermentation converts the starch and sugars of potato pulp into volatile fatty acids, alcohol and lactic acid (Prescott et al., 1996). These fermentation products are considered highly palatable and may have the potential to increase the feed intake of the pigs (Scholten et al., 1999). In our previous work with lactating sows, feeding fermented potato pulp significantly increased feed intake (Xue et al., 2011). However, in the current study, fermented potato pulp increased feed intake only in experiment 2 (56-78 kg). Fermented potato pulp was used in the level of 5% in each phase. The optimum level of fermented potato pulp for maximize growth performance perhaps would be different in different phase, therefore, the growth performance responded differently in 3 phases.

The effects of fermented potato pulp on the apparent total track digestibility of nutrients are shown in Table 4. Dietary fermented potato pulp increased (p<0.05) dry matter digestibility in experiments 1 (25-45 kg) and 3 (86-109 kg). In experiment 2 (56-78 kg), fermented potato pulp increased the digestibility of gross energy (p<0.05) and tended to increase the digestibility of dry matter (p<0.10).

Table 3. Effect of fermented potato pulp on the performance of growing-finishing pigs[1]

	Fermented potato pulp (%)		SEM	p value
	0	5		
Experiment 1 (25-45 kg)				
Initial BW (kg)	25.6	25.6	0.13	0.92
Final BW (kg)	44.6	45.4	0.16	0.01
Weight gain (g/d)	678	706	7.00	0.03
Feed intake (g/d)	1,620	1,620	20.00	0.71
Feed conversion	2.43	2.34	0.02	0.08
Experiment 2 (56-78 kg)				
Initial BW (kg)	56.3	56.2	0.29	0.85
Final BW (kg)	77.2	78.8	0.40	0.04
Weight gain (g/d)	745	808	8.00	0.01
Feed intake (g/d)	2,060	2,100	10.00	0.03
Feed conversion	2.78	2.67	0.03	0.04
Experiment 3 (86-109 kg)				
Initial BW (kg)	86.3	86.4	0.36	0.85
Final BW (kg)	108.9	109.4	0.39	0.48
Weight gain (g/d)	806	821	6.25	0.24
Feed intake (g/d)	3,030	3,010	10.00	0.34
Feed conversion	3.80	3.69	0.03	0.08

[1] Value represent means of six pens with 15-20 pigs per pen during a 28-d period.

Table 4. Effect of fermented potato pulp on nutrient digestibility (%) in growing-finishing pigs[1]

	Fermented potato pulp (%)		SEM	p value
	0	5		
Experiment 1 (25-45 kg)				
Dry matter	79.34	81.49	0.48	0.02
Energy	81.46	80.63	0.60	0.52
Crude protein	76.81	76.23	0.39	0.48
Experiment 2 (56-78 kg)				
Dry matter	81.55	84.40	0.78	0.07
Energy	80.44	82.92	0.63	0.04
Crude protein	79.96	81.59	0.56	0.15
Experiment 3 (86-109 kg)				
Dry matter	74.51	77.16	0.52	0.02
Energy	80.44	80.33	0.28	0.85
Crude protein	74.39	73.77	0.37	0.43

[1] Value represent means of six pens with 15-20 pigs per pen during a 28-d period.

These increases in nutrient digestibility may help to explain the improvements in pig performance observed when fermented potato pulp is fed.

Fermentation of diets has previously been shown to improve nutrient digestibility for pigs (Min et al., 2004; Kim et al., 2007). Dung et al. (2005) observed increased dry matter and crude protein digestibility when pigs were fed fermented diets. This is similar to the results of Hong and Lindberg (2007). Also, Lyberg et al. (2006) found fermentation of diets improved the apparent ileal digestibility of dry matter. A potential explanation for the increase in nutrient digestibility may be that microbial activity occurring during fermentation decreases the fiber fraction in the diet (Pedersen and Lindberg, 2003) and improves the bacterial ecology of the pig's gastrointestinal tract (Canibe et al., 2008).

The effects of fermented potato pulp on plasma parameters in growing-finishing pigs are shown in Table 5. Plasma urea nitrogen was decreased ($p<0.05$) in pigs fed fermented potato pulp in experiments 1 and 2. This result is consistent with Cho et al. (2007) and Dung et al. (2005) who reported that plasma urea nitrogen was altered by feeding fermented diets. It has been suggested that plasma urea nitrogen is a useful index to evaluate protein quality (Eggum, 1970). The concentration of crude protein is only 0.5% in wet potato pulp (Mayer, 1998), but the fermented potato pulp used in present study contained 9.20% crude protein. The increase in protein content is likely due to the addition of microbial protein which typically is very high in protein quality. Therefore, the reduction in plasma urea nitrogen reflects the high protein quality of the fermented diet allowing its amino acids to be more effectively utilized for synthesizing tissue protein. Although the dietary AA concentrations were similar in 2 diets for each phase, probably reason for this may be the peptides produced by fermentation (Kim, 2004; Cho and Kim, 2011). It is reported that peptides were absorbed easily than AA in the small intestine (Ganapathy and Leibach, 1999).

The concentration of alanine aminotransferase was lower ($p<0.05$) when pigs were fed fermented potato pulp in experiments 1 and 2 while aspartate aminotransferase was decreased ($p<0.05$) in experiment 3. Measurement of these enzymes is typically used to assess liver (Beckett et al., 1989) and cellular damage (Kim and Mahan, 2001). In the present study, the fact that these enzymes were decreased and not increased while the concentration of the other plasma parameters measured were also not altered provides at least cursory evidence that fermented potato pulp does not contain any toxic compounds likely to be deleterious to the animal.

Dietary fermented potato pulp did not affect the carcass characteristics of the finishing pigs in experiment 3 (Table 6). There is limited information on how the carcass characteristics of pigs are affected by fermented potato pulp. Radunz et al. (2003) reported that the fat thickness and loin area of beef was decreased by dietary potato pulp at a level from 0 to 40% for 97 d. In contrast, Nelson (2010) found no effects of potato pulp on carcass characteristics of finishing cattle. Urlings et al. (1993) demonstrated that feeding fermented feed increased backfat thickness and decreased meat percentage in finishing pigs. However, replacing 15% of the barley in pig diets with pressed beet pulp silage had no effect on carcass parameters (Scipioni and Martelli, 2001).

The effects of fermented potato pulp on fecal noxious gases in growing-finishing pigs are shown in Table 7. Fermented potato pulp significantly ($p<0.05$) decreased the concentration of ammonia in feces in experiments 1 to 3. Awati et al. (2006) found that fermented feed decreased the fecal concentration of ammonia of weanling pigs because

Table 5. Effect of fermented potato pulp on plasma parameters in growing-finishing pigs[1]

	Fermented potato pulp (%)		SEM	p value
	0	5		
Experiment 1 (25-45 kg)				
Plasma urea nitrogen (mmol/L)	5.26	4.48	0.16	<0.01
Alanine aminotransferase (IU/L)	38	30	1.77	<0.01
Aspartate aminotransferase (IU/L)	41	45	1.92	0.28
Total cholesterol (mmol/L)	2.33	2.46	0.09	0.47
Low-density lipoprotein (mmol/L)	1.28	1.29	0.06	0.90
High-density lipoprotein (mmol/L)	0.90	0.87	0.03	0.67
Creatinine (umol/L)	93	88	2.08	0.26
Experiment 2 (56-78 kg)				
Plasma urea nitrogen (mmol/L)	6.09	5.29	0.20	0.03
Alanine aminotransferase (IU/L)	51	44	1.69	0.04
Aspartate aminotransferase (IU/L)	80	68	4.73	0.19
Total cholesterol (mmol/L)	2.13	2.26	0.09	0.50
Low-density lipoprotein (mmol/L)	1.24	1.36	0.05	0.27
High-density lipoprotein (mmol/L)	0.79	0.78	0.02	0.80
Creatinine (umol/L)	105	105	4.48	0.96
Experiment 3 (86-109 kg)				
Plasma urea nitrogen (mmol/L)	6.87	6.26	0.34	0.38
Alanine aminotransferase (IU/L)	52	58	4.02	0.49
Aspartate aminotransferase (IU/L)	178	110	15.03	0.02
Total cholesterol (mmol/L)	2.16	2.34	0.09	0.35
Low-density lipoprotein (mmol/L)	1.41	1.49	0.09	0.69
High-density lipoprotein (mmol/L)	0.62	0.67	0.03	0.49
Creatinine (μmol/L)	140	134	6.05	0.66

[1] Value represent means of six pens with one pig per pen.

Table 6. Effect of fermented potato pulp on carcass characteristics in finishing pigs (Exp. 3)[1]

	Fermented potato pulp (%)		SEM	p value
	0	5		
Dressing percentage (%)	68.94	69.92	1.09	0.67
Loin area (cm^2)	42.01	43.97	0.85	0.26
3-4th-rib back fat thickness (mm)	39.4	39.3	1.23	0.97
10th-rib back fat thickness (mm)	20.3	19.2	0.93	0.57
Last rib back fat thickness (mm)	21.9	20.3	1.07	0.47
$pH_{45\ min}$	6.32	6.30	0.05	0.89
$pH_{24\ h}$	5.50	5.56	0.02	0.17
Meat color				
L* (Lightness)	53.09	52.73	0.95	0.85
a* (Redness)	8.04	6.77	0.39	0.11
b* (Yellowness)	5.64	4.96	0.31	0.28

[1] Value represent means of six pens with one pig per pen.

Table 7. Effect of fermented potato pulp on fecal noxious gases in pig feces[1]

	Fermented potato pulp (%)		SEM	p value
	0	5		
Experiment 1 (25-45 kg)				
Carbon dioxide (mg/kg)	1,112	1,042	84	0.70
Ammonia (mg/m^3)	27	22	1.23	0.03
Experiment 2 (56-78 kg)				
Carbon dioxide (mg/kg)	2,145	1,820	125	0.21
Ammonia (mg/m^3)	30	23	1.26	<0.01
Experiment 3 (86-109 kg)				
Carbon dioxide (mg/kg)	1,385	1,215	95	0.40
Ammonia (mg/m^3)	33	27	1.62	0.04

[1] Value represent means of six pens with three pigs per pen.

the fermentation of protein was reduced in the gastrointestinal tract.

Ammonia is a major concern causing environmental pollution (Zahn et al., 1997) and is harmful to the health of both pigs and workers in a pig farm (Chung et al., 1996). Because it is known that land application of excessive quantities of ammonia nitrogen is subject to run-off and leaching that could contaminate ground or surface waters, the reduction in fecal ammonia excretion due to feeding fermented potato pulp could minimize the environmental impact of intensive swine operations and reduce the amount of nitrogen lost from these facilities that could potentially pollute the environment.

In conclusion, feeding growing-finishing pigs diets containing 5% fermented potato pulp improved weight gain and feed conversion without any detrimental effects on carcass traits. The improvements in pig performance appeared to be mediated by improvements in nutrient digestibility. Fermented potato pulp also decreased ammonia levels in swine feces. Therefore, feeding fermented potato pulp could provide both economic and environmental benefits in the same package.

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