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EFFECT OF FIBRE LEVEL AND FIBRE SOURCE ON NITROGEN AND PHOSPHORUS EXCRETION, AND HYDROGEN SULPHIDE, AMMONIA AND GREENHOUSE GAS EMISSIONS FROM PIG SLURRY

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ABSTRACT

This study was carried out to evaluate the effect of different fibre levels and fibre sources in the pig diet on nitrogen (N) and phosphorus (P) excretions, and ammonia (NH_3), hydrogen sulphide (H_2S) and greenhouse gas (GHG) emissions from slurry. A total of 24 pigs with the initial body weight (BW) around 24 ± 0,25 kg were kept individually in concrete floored pens (1.8 m x 0.8 m) in an open-sided house. The experiment was structured according to a completely randomized 2 x 2 factorial design, with two fibre sources [tofu residue (TFR) and coconut cake (CC)] and two fibre levels [low fibre (LF) and high fibre (HF)]. Each treatment consisted of 6 pens, with one pig per pen as a replicate. Results show that, in growing period, pigs fed LF diet had higher slurry pH and lower N excretion than those in pigs fed HF diet (P > 0.05). Fibre source and fibre level had no effects on the slurry characteristics and the excretion of slurry DM and P (P > 0.05). The CH_4 emission was higher for the diet CC than for the diet TFR (P > 0.05). Increased dietary fibre level resulted in increased the CH_4 and CO_2 emission, and decreased NH_3 emission (P > 0.05). In fattening period, slurry chemical characteristics, N and P excretion were not effected by fibre source and fibre level (P > 0.05). Pigs fed diet TFR had greater the NH_3 emission from slurry than those in pigs fed diet CC (P > 0.05). The H_2S and CO_2 emissions were not affected by fibre level (P > 0.05). Pigs fed HF diet showed higher CH_4 emission than those pigs fed LF diet, while NH_3 emission was significantly higher in LF than that in HF diet (P > 0.05).

Keywords: Excretion, fibre level, fibre sourse, gas emission, pig diet, slurry.

Ảnh hưởng của mức xơ và nguồn xơ trong khẩu phần ăn đến phát thải nitơ, phôtpho, hydro sulfua, ammoniac và khí nhà kính từ chất thải của lợn thịt

TÓM TẮT

Nghiên cứu này nhằm xác định ảnh hưởng của mức xơ và nguồn xơ trong khẩu phần ăn đến phát thải nitơ, photpho, hydro sulfua, ammoniac và khí nhà kính từ chất thải của lợn thịt. Tổng số 24 lợn con (giống ngoại) có khối lượng ban đầu 24 ± 0,25 kg được nuôi cá thể trong chuồng nuôi với diện tích 0,8m x 2,2 m. Thí nghiệm được thiết kế ngẫu nhiên hoàn toàn với 2 nhân tố là mức xơ (mức cao và thấp) và nguồn xơ (bã đậu phụ và bã dầu dừa) với 6 lần lặp lại. Kết quả cho thấy, ở giai đoạn sinh trưởng, lợn ăn khẩu phần xơ thấp có giá trị pH chất thải cao hơn và N bài tiết thấp hơn so với lợn ăn khẩu phần xơ cao (P > 0,05). Mức xơ và nguồn xơ không ảnh hưởng đến vật chất khô (VCK) chất thải, hàm lượng N và P trong chất thải, và lượng VCK và P bài tiết (P > 0,05). Sự phát thải khí CH_4 ở khẩu phần khô dừa cao hơn so với khẩu phần bã đậu phụ. Tăng hàm lượng xơ trong khẩu phần đã làm tăng phát thải khí CH_4, CO_2 và làm giảm phát thải khí NH_3 (P > 0,05). Ở giai đoạn vỗ béo, đặc tính hóa học của chất thải hay lượng N và P bài tiết không bị ảnh hưởng bởi mức xơ và nguồn xơ trong khẩu phần (P > 0,05). Lượng khí NH_3 phát thải ở lợn ăn khẩu phần bã đậu phụ cao hơn so với ở lợn ăn khẩu phần khô dừa (P > 0,05). Mức xơ trong khẩu phần không có tác động đến sự phát thải khí H_2S và CO_2 (P > 0,05). Tăng hàm lượng xơ trong khẩu phần đã làm tăng sự phát thải khí CH_4, trong khi đó giảm hàm lượng xơ trong khẩu phần lại làm tăng sự phát thải khí NH_3 (P > 0,05).

Từ khóa: Chất thải, khẩu phần, lợn thịt, mức xơ, nguồn xơ, phát thải khí, sự bài tiết.

1. INTRODUCTION

In most countries pig production is often concentrated in limited areas. This renders some economic advantages but it also causes environmental damage due to the emission of greenhouse gas (GHG) and ammonia. Slurry from livestock farm is the mainly source of CH_4 and CO_2, and it has huge potential for renewable energy production. Such a release of CH_4 from animal manure to atmosphere, due to anaerobic digestion of organic matter, accounts for about 4% of the anthropogenic GHG emission (Hashimoto et al., 1981). Efforts have been made on animal nutrition to contribute to a more sustainable manure management. Diet composition can affect the amount and composition of faeces and urine, and therefore gas emissions (Hansen et al., 2007; Massé et al., 2003). The recent peak in the price of cereals has highlighted the competition between the use of cereals for animal feed and for human consumption. In this context, the use of by-products from food production or biofuel processing would be suggested as a relevant economic alternative.

Increasing dietary fibre in pig diets increases the fermentation rates in the large intestine, shifting N partition from urine to faeces; it also increases the excretion of short fatty acids (SCFA) and decreases the pH of faeces (Canh et al., 1997). Moreover, it has been shown that changes in type and content of NSP in the diet may alter the manure composition and may influence CH_4 emission (Canh et al., 1998; Jarret et al., 2011).

In Viet Nam, common feed ingredients in pig diets, particularly at small-holder farm level, derive primarily from vegetation and agro-industry by-products, such as sweet potato vines, water spinach, rice bran, tofu residues (TFR), coconut cake (CC), cassava residue and brewer's grains. These feed ingredients are readily available, cheap and well accepted by pigs. However, the high fibre content may be a constraint for feed intake, and may impair performance and feed utilization. In addition to fibre level, solubility and the degree of lignification (Bach Knudsen, 1997) of the fibre fraction may be of importance for its utilization. Tofu residues are high in soluble non-starch polysaccharides (NSP) while CC is high in insoluble NSP as fibrous dietary ingredient sources (Ngoc et al., 2012). These differences between fibre sources are expected to affect the slurry composition and GHG emissions. The approach recently attracting investigations in reducing N, P excretion and GHG emission is to use different fibre levels and fibre souces in the diets for pigs.

2. MATERIALS AND METHODS

2.1. Location

The experiment was carried out at Center of Animal Feed Testing and Conservation, National Institute of Animal Sciences (NIAS), from November 2013 to October 2014.

2.2. Experimental feeds

The experimental diets were formulated according to NRC (1998). The low fibre diets (LF), containing around 190-200 g NDF/kg dry matter (DM), and the high fibre diets (HF), containing around 250-260 g NDF/kg DM, were be formulated with or without TFR and CC as feed ingredients. All diets were formulated to be equal in metabolizable energy, Ca, P and essential amino acids. The ingredient and chemical composition of diets are presented in Table 1.

2.3. Animals and experimental design

A total of 24 pigs with the initial body weight (BW) of pigs (Landrace x Yorkshire x Duroc) around 24 kg was used in this experiment. Before the start of experiment, all animals were vaccinated against Hog cholera, Pasteurellosis, Pneumonia and Paratyphoid. The pigs were kept individually in concrete floored pens (1.8 m x 0.8 m) in an open-sided house. The pen has a slatted floor at the rear and has a separate manure pit (110 cm length x 50 cm width x 40 cm depth) per pen under the slatted

Table 1. Ingredient and chemical composition of the experimental diets

Item	Growing pigs				Fattening pigs			
	Tofu residue		Coconut cake		Tofu residue		Coconut cake	
	Low fibre	High fibre	Low fibre	High fibre	Low fibre	High fibre	Low fibre	High fibre
Ingredient composition (g/kg air-dry basis)								
Maize	58.3	43.8	58.26	45.21	57.25	46.55	58.4	45.05
Soybean meal	19	14	19	14.5	16	12	16.5	11.5
Fish meal	4	4	4	4				
Wheat bran	10	17	10	16	12	15	12	17
Tofu residue	5	16	0	0	10.3	20	0	0
Coconut cake	0	0	5	15	0	0	9	20
Soybean oil	1.5	3	1	2.5	2	4	1.5	3.8
Dicalcium phosphate	0.5	0.5	1	0.95	0.8	1.1	0.8	0.4
Limestone	0.9	0.9	0.9	0.9	0.9	0.6	0.9	1.2
Mineral-vitamin premix[a]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.05	0.05	0.09	0.18	0	0	0.1	0.2
Methionine	0	0	0.05	0.09	0	0	0.05	0.1
Salt (NaCL)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
DM (g/kg air-dry basis)	88.99	88.25	88.74	88.36	88.91	88.06	88.85	88.37
Chemical composition (g/kg air-dry basis)								
Crude protein	17.99	17.93	18.02	17.95	15.33	15.38	15.32	15.31
Crude fibre	4.93	6.28	4.88	6.12	5.42	6.45	5.32	6.39
NDF	18.90	23.93	19.03	24.06	20.31	25.72	20.56	26.34
Ca	0.74	0.75	0.76	0.75	0.64	0.63	0.64	0.64
P	0.64	0.62	0.65	0.63	0.52	0.55	0.56	0.54
Lysine	0.98	0.97	0.97	0.96	0.79	0.80	0.77	0.75
Methionine+Cystein	0.54	0.56	0.55	0.53	0.49	0.50	0.49	0.47
Threonine	0.63	0.65	0.64	0.61	0.53	0.54	0.52	0.51
Tryptophan	0.21	0.22	0.20	0.19	0.16	0.17	0.17	0.15
ME (MJ/kg air-dry basis)	13.12	13.01	13.09	12.99	13.08	13.01	13.09	13.05

Note: [a] Content per kg of air dry diet. Vitamins: A, 2000 IU; D_3, 400 IU; E, 12.5 mg; K, 3 mg; B1, 2.5 mg; B12, 100 IU; Ca, 0.275 g; Cu, 27.5 mg; Fe, 25 mg; Zn, 37 mg; Co, 0.5 mg; Iodine, 0.38 mg; Se, 0.11 mg.

floor. The experiment was structured according to a completely randomized 2 x 2 factorial design, with two fibre sources (TFR and CC) and two fibre levels (LF and HF). Each treatment consisted of 6 pens, with one pig per pen as a replicate. The experiment lasted 90 days.

Pigs were fed with 4.0% of the BW. The amount of feed intake was adjusted each day according to the expected BW gain. The pigs accessed feed and water by mixing with the ratio 1:4 (w/w). Apart from water with feed, the pigs were not given any additional water in order to ensure similar amount of feed and water intake. Animals were fed 2 times per day at 08h30 and 15h30. Feed intake was recorded daily. The pigs were weighed at the beginning and at the end of the experimental period before the morning feeding.

2.4. Measurements and data collection

In each experimental period, after an adaptation period of 10 days, pens and manure pits were cleaned. Subsequently feces and urine were accumulated together in the manure pit.

Feces and urine were accumulated for 32 days. Air samples for NH_3 and H_2S emission measurements were collected between 9h00 and 14h00 and for GHG emission measurement between 9h00 and 12h00 of the sampling days.

2.4.1. Measuring and calculating ammonia emission

After 32 days of urine and feces accumulation in the manure pit, samples for determining NH_3 emission were collected directly from air above the manure pits according to the method of Le et al. (2009). One air sample for NH_3 emission measurement was collected from each manure pit. Thus, there were 24 air samples for NH_3 emission measurement in total. Ammonia emission from the manure pit was calculated using equation 1.

$$MNH_3 = (CNH_3 \times V \times 10.000) / (T \times 60 \times S) \quad [1]$$

Where MNH_3 = ammonia emission (mg s^{-1} m^{-2}), CNH_3 = ammonia concentration (mgmL^{-1} HNO_3),V = volume of HNO_3 (mL), 10.000 = cm^2m^{-2}, T = sampling time (10 minutes), 60 = s min^{-1}, S = emitting surface in cm^2.

2.4.2. Measuring and calculating hydrogen sulfide emission

The principle of measuring and calculating H_2S emission was similar to ammonia. Hydrogen sulfide emission was calculated with equation 1, in which the volume of HNO_3 was replaced by that of 0.1M $CdSO_4$. Hydrogen sulfide was trapped by Cadimi Sulfate 0.1M in the impinges.

2.4.3. Measuring and calculating greenhouse gas emission

Air samples for GHG emission were collected at 30 after urine and fecal accumulaion in the manure pit. On each sampling day, three air samples were collected at 0, 20 and 40 minutes after placing the sampling vessel in the middle of the manure pit. The volume of the vessel was 63.36 l (0.55 m x 0.32 m x 0.36 m).

In total there were 144 air samples for GHG emission measurement (4 treatments x 6 replications x 3 sampling times/day x 2 periods). Greenhouse gas samples were collected from the air in the chamber. A syringe and a needle was used to draw about 20 mL air from the vessel through a valve. One syringe was used for one GHG sample. The samples were kept in a cool place until analyses of CH_4 and CO_2 by gas chromatography (Bruker 450 - GC 2011) as described by Le et al. (2009). Greenhouse gas emission was estimated by the method of Smith and Conen (2004).

2.4.4. Collection and measurement of slurry characteristics

One manure sample was collected from each manure pit. After collecting air samples on 32th day, slurry in each slurry pit was mixed thoroughly pior to sampling about 1 kg. Slurry samples were stored at -20^{0}C until analysis. Slurry samples were analyzed for dry matter, total nitrogen, phosphorus and pH.

2.4.5. Chemical analysis

Dry matter (967.03), total nitrogen (984.13), ash (942.05), P and Ca were analysed according to the standard AOAC methods (AOAC, 1990). The NDF content was determined by the method of Van Soest et al. (1991). Slurry pH was determined by pH meter HI 8424 HANNA (Made in Mauritius).

2.5. Data analysis

The data were analysed as a 2×2 factorial completely randomized design using the GLM procedure of Minitab Software, version 13.31 (Minitab, 2000). Pair-wise comparisons with a confidence level of 95% was used to determine the effects of dietary treatment between groups.

3. RESULTS

Fibre source and fibre level did not affect DM intake (DMI) ($P > 0.05$) in any of the periods (Table 2 and 3). The LF diet supported faster growth and better feed efficiency than the HF diet ($P > 0.05$) in both growing and fattening periods. In growing period (Table 2), diet TFR yielded higher average daily gain (ADG) than that in diet CC (P > 0.05), while there was no difference in FCR between TFR and CC diets (P > 0.05). In the fattening period (Table 3), the fibre sources did not statistically affect ADG and FCR (P > 0.05).

Table 2. Effect of fibre level and fibre source on feed intake, average daily gain (ADG) and feed conversion ratio (FCR) of growing pigs (20-50 kg)

	Initial BW (kg)	Final BW (kg)	ADG (g/head/day)	Feed intake (kg/head/day)	FCR (kg feed/kg gain)
Fibre source (FS)					
Tofu residue	24.10	50.43	642	1.57	2.47
Coconut cake	24.10	48.90	605	1.51	2.52
Fibre level (FL)					
High fibre	24.20	48.46	592	1.53	2.60
Low fibre	24.00	50.87	655	1.56	2.39
Fibre source x Fibre level (FS x FL)					
TFR-HF	24.20	49.42	615	1.59	2.60
TFR-LF	24.00	51.44	669	1.56	2.34
CC-HF	24.20	47.50	568	1.47	2.60
CC-LF	24.00	50.30	641	1.56	2.44
SEM	0.256	0.770	16.77	0.023	0.057
P-value					
FS	0.449	0.009	0.003	0.182	0.400
FL	0.999	0.070	0.047	0.064	0.003
FS x FL	0.999	0.662	0.593	0.024	0.400

Note: TFR: Tofu residue; CC: Coconut cake; HF: High fibre; LF: Low fibre

Table 3. Effect of fibre level and fibre source on feed intake, average daily gain (ADG) and feed conversion ratio (FCR) of fattening pigs (50-80 kg)

	Initial BW (kg)	Final BW (kg)	ADG (g/head/day)	Feed intake (kg/head/day)	FCR (kg feed/kg gain)
Fibre source (FS)					
Tofu residue	49.68	80.90	781	2.58	3.32
Coconut cake	49.65	80.45	770	2.58	3.38
Fibre level (FL)					
High fibre	49.76	79.35	740	2.58	3.51
Low fibre	49.57	82.00	770	2.58	3.19
Fibre source x Fibre level (FS x FL)					
TFR-HF	49.76	79.60	746	2.61	3.52
TFR-LF	49.60	82.20	815	2.56	3.12
CC-HF	49.76	79.10	734	2.56	3.50
CC-LF	49.54	81.80	807	2.61	3.26
SEM	0.490	1.092	26.41	0.055	0.131
P-value					
FS	0.952	0.688	0.698	0.969	0.654
FL	0.705	0.032	0.020	0.974	0.031
FS x FL	0.952	0.964	0.938	0.346	0.552

Note: TFR: Tofu residue; CC: Coconut cake; HF: High fibre; LF: Low fibre

The effects of fibre sources and fibre levels on slurry chemical characteristics and N, P excretions in the growing and fattening pigs are presented in Table 4 and 5, respectively. In growing time, pigs fed the diet TFR had higher N intake than pigs fed the diet CC ($P > 0.05$), while N intake was similar between LF and HF diets ($P > 0.05$). In contrast, P intake was higher in LF diet than in HF diet ($P > 0.01$) and it did not differ between diets TFR and CC ($P > 0.05$). The N excretion was lower in LF diet compared to that in HF diet ($P > 0.05$), whereas pigs fed LF diet had higher slurry pH than pigs fed HF diet ($P > 0.05$). Fibre source and fibre level did not effects on the content of slurry DM (%), N and P (% DM basis), and the excretion of slurry DM (kg/head/day) and P (g/head/day) ($P > 0.05$). In fattening period (Table 5), N and P intake, slurry chemical characteristics, and N and P excretions were not affected by fibre source and fibre level ($P > 0.05$).

In the growing period (Table 6), the NH_3, H_2S and CO_2 emissions were similar in diets TFR and CC ($P > 0.05$), whereas CH_4 emission was higher in diet CC than in diet TFR (P > 0.05. With exception of H_2S emission, fibre level affected the NH_3, CH_4 and CO_2 emission ($P > 0.05$). Increasing dietary fibre level resulted in increased CH_4 and CO_2 emission, and decreased NH_3 emission. In the fattening period (Table 7), the fibre source did not affected the H_2S, CH_4 and CO_2 emission from pig slurry ($P > 0.05$), with the exception of NH_3 emission ($P > 0.05$). Pigs fed diet TFR had greater the slurry NH_3 emission than pigs fed diet CC. The H_2S, and CO_2 emissions were not affected by fibre level ($P > 0.05$). Pigs fed HF diet showed higher CH_4 emission than pigs fed LF diet ($P > 0.05$), while LF diet supported greater NH_3 emission compared to that of HF diet ($P > 0.05$).

Table 4. Effects of fibre level and fibre source on slurry chemical characteristics and nitrogen (N) and phosphorus (P) excretion in the growing pigs (20-50 kg)

	N intake (g/head/day)	P intake (g/head/day)	Slurry DM content (%)	Slurry amount (kg DM head/ day)	Slurry pH	ExcretaN (% DM)	Excreta P (% DM)	Excreta N (g/head/day)	Excreta P (g/head/day)
Fibre source (FS)									
Tofu residue	45.21	9.91	16.08	0.26	7.40	3.68	1.68	9.40	4.23
Coconut cake	43.52	9.69	16.83	0.27	7.35	3.83	1.73	10.29	4.63
Fibre level (FL)									
High fibre	43.82	9.54	16.92	0.28	7.32	4.09	1.76	11.10	4.72
Low fibre	44.90	10.06	15.98	0.25	7.43	3.43	1.65	8.60	4.14
Fibre source x Fibre level (FS x FL)									
TFR-HF	45.51[a]	9.83[ab]	16.46	0.27	7.34	3.88	1.71	10.29	4.48
TFR-LF	44.91[a]	9.98[a]	15.69	0.24	7.46	3.49	1.65	8.51	3.98
CC-HF	42.14[b]	9.25[b]	17.39	0.28	7.31	4.30	1.81	11.90	4.97
CC-LF	44.90[a]	10.13[a]	16.27	0.26	7.40	3.37	1.66	8.68	4.29
SEM	0.65	0.15	1.32	0.028	0.04	0.46	0.195	1.05	0.37
P-value									
FS	0.024	0.163	0.496	0.620	0.319	0.736	0.789	0.412	0.306
FL	0.124	0.004	0.398	0.291	0.032	0.163	0.578	0.035	0.140
FS x FL	0.024	0.025	0.872	0.837	0.669	0.553	0.827	0.505	0.820

Note: TFR: Tofu residue; CC: Coconut cake; HF: High fibre; LF: Low fibre; Within a column and factor values with different letters are significantly different

Table 5. Effects of fibre level and fibre source on slurry chemical characteristics and nitrogen (N) and phosphorus (P) excretion in the growing pigs (50-80 kg)

	N intake (g/head /day)	P intake (g/head /day)	Slurry DM content (%)	Slurry amount (kg DM head/ day)	Slurry pH	Excreta N (% DM)	Excreta P (% DM)	Excreta N (g/head/day)	Excreta P (g/head/day)
Fibre source (FS)									
Tofu residue	63.39	13.81	17.11	0.40	6.54	4.02	1.63	15.96	6.45
Coconut cake	63.17	14.18	18.22	0.43	6.36	4.09	1.65	17.15	7.03
Fibre level (FL)									
High fibre	63.30	14.05	18.02	0.40	6.40	4.17	1.81	16.72	7.36
Low fibre	63.26	13.94	17.32	0.42	6.49	3.94	1.48	16.39	6.12
Fibre source x Fibre level (FS x FL)									
TFR-HF	64.13	14.33[ab]	17.56	0.39	6.50	4.06	1.74	16.05	6.93
TFR-LF	62.64	13.28[a]	16.67	0.41	6.58	3.99	1.52	15.88	5.98
CC-HF	62.47	13.77[ab]	18.47	0.41	6.30	4.27	1.87	17.40	7.79
CC-LF	63.87	14.59[b]	17.97	0.44	6.41	3.90	1.44	16.90	6.27
SEM	1.341	0.292	1.37	0.030	0.112	0.28	0.154	1.91	0.82
P-value									
FS	0.877	0.227	0.229	0.536	0.129	0.824	0.887	0.309	0.438
FL	0.976	0.698	0.439	0.511	0.443	0.440	0.054	0.771	0.112
FS x FL	0.303	0.008	0.826	0.888	0.910	0.589	0.500	0.887	0.700

Note: TFR: Tofu residue; CC: Coconut cake; HF: High fibre; LF: Low fibre; Within a column and factor values with different letters are significantly different

Table 6. Effects of fibre level and fibre source on NH_3, H_2S and greenhouse gas emission in the growing pigs (20-50 kg)

	H_2S (mg/m^3)	NH_3(mg/m^3)	CH_4 (g/head/30 days)	CO_2 (g/head/30 days)
Fibre source (FS)				
Tofu residue	1.28	4.99	67.3	716
Coconut cake	1.22	5.04	75.2	748
Fibre level (FL)				
High fibre	1.24	4.91	77.4	758
Low fibre	1.27	5.14	65.4	707
Fibre source x Fibre level (FS x FL)				
TFR-HF	1.27	4.95	74.6	742
TFR-LF	1.30	5.05	60.0	691
CC-HF	1.21	4.87	80.1	774
CC-LF	1.24	5.23	70.3	723
SEM	0.047	0.087	3.59	22.1
P-value				
FS	0.215	0.539	0.049	0.174
FL	0.521	0.023	0.005	0.041
FS x FL	0.934	0.152	0.520	0.930

Note: TFR: Tofu residue; CC: Coconut cake; HF: High fibre; LF: Low fibre.

Table 7. Effects of fibre level and fibre source on NH_3, H_2S and greenhouse gas emission in the growing pigs (50-80 kg)

	H_2S (mg/m^3)	NH_3(mg/m^3)	CH_4 (g/head/30 days)	CO_2 (g/head/30 days)
Fibre source (FS)				
Tofu residue	1.31	5.87	82.3	1064
Coconut cake	1.37	5.25	90.2	1102
Fibre level (FL)				
High fibre	1.38	5.29	91.5	1116
Low fibre	1.30	5.82	81.0	1050
Fibre source x Fibre level (FS x FL)				
TFR-HF	1.40	5.61	88.1	1091
TFR-LF	1.23	6.12	76.5	1036
CC-HF	1.36	4.97	94.9	1141
CC-LF	1.38	5.52	85.4	1064
SEM	0.105	0.228	4.34	47.7
P-value				
FS	0.599	0.018	0.093	0.432
FL	0.457	0.037	0.032	0.191
FS x FL	0.385	0.914	0.821	0.828

Note: TFR: Tofu residue; CC: Coconut cake; HF: High fibre; LF: Low fibre;

In both periods, there were no interactions between fibre level and fibre source on feed intake, ADG and FCR, slurry chemical characteristics, N and P excretion, NH_3, H_2S, CH_4 and CO_2 emission ($P > 0.05$).

4. DISCUSSION

The use of TFR or CC in the diet for growing and fattening pigs resulted in similar DM intake (DMI). In contrast, Ngoc et al. (2013) showed that the lower DMI was HF diet containing cassava residue compared with HF diet containing brewer's grains, this could be related to the higher water holding capacity of cassava residue as compared with brewer's grain (Ngoc et al., 2012). The water holding capacity of a feedstuff is related to its bulking properties and will affect the feed intake capacity (Kyriazakis and Emmans, 1995). In the growing period, pigs fed the TFR diet improved ADG compared to pigs fed the CC diets, this could be due to an association of higher digestibility of gross energy (GE) and dietary components in the TFR diet. However, in the fattening period ADG and FCR were similar between diets TFR and CC. Thus, apparently the animal response to diets containing different fibrous feed sources may relate to the age of animals.

In recent study, dietary fibre level did not affect DMI of pigs in any of the periods. Similarly, Len et al. (2009a) found no difference in DMI of pigs fed low and high fibre diets based on rice bran, sweet potato vines and cassava residues. In contrast, the study of Ngoc et al. (2013) indicated that pigs fed the HF diets compensated a lower dietary content of metabolisable energy (ME) by consuming more DM than on LF diet. Pigs fed LF diet exhibited greater ADG and improved FCR compared to pigs fed HF diet in both growing and fattening periods. The results are in line with Len et al. (2009a, b) and Ngoc et al. (2013).

The N excretion in growing pigs was lower in the LF diet compared to that in the HF diet, this could be explained that when more fibre content are included in the diet, more N will be excreted via the feces in the form of bacterial protein and less via the urine in the form of urea. Our result was in contrast with results from other studies (Canh et al., 1997; Zervas & Zijlstra, 2002), where there was no difference in N excretion between high and low fibre levels, although N excretion in feces was increased and N excretion in urine was decreased. However, N excretion in fattening period was not effected by dietary fibre level. This could be due to the digestive capacity in pigs improves with age as the enzyme system matures and gut microbial population increases (Lindemann et al., 1986), leading to fattening pigs have a greater capacity to digest dietary components of fibrous diet than growing pigs.

The present study showed that the LF diet given higher slurry pH compared to the HF diet. This was in accordance with result from other study by Canh et al. (1998). According to Sommer and Husted (1995), the slurry pH is of great importance for the NH_3 emission from pig slurry. Because the effect of pH on NH_3 emission is very strong, a minor change in pH can have a large effect. In this study, the source and the level of fibre in the diet are important factors affecting the pH and the NH_3 emission. Increasing the amounts of fibre level in the diet enhanced the microbial activities in the hindgut of pigs and in the slurry during storage and thus increased volatile fatty acid (VFA) formation in the feces and slurry (O'Shea et al., 2009). This lowered the pH of the slurry and thereby leading to reduce the NH_3 emission. This was confirmed by Canh et al. (1998), the pH of slurry and the NH_3 emission were negatively related to the intake of dietary NSP, and thus a high intake of dietary NSP increased the total VFA concentration and reduced the pH and the NH_3 emission. When increasing dietary fibre level, the reduction of NH_3 emission was greater with fattening pigs (10%) than growing pigs (5%), in contrast to result from Philippe et al. (2015), who reported that the reduction of NH_3 emission was lower with gestating sows than fattening pigs.

Hydrogen sulfide is the most important odor causing compounds in terms of strength and offensiveness. Reducing H_2S emission has been given first priority in odor reduction strategies. The emission of H_2S in this study did not shown any significant difference regarding the dietary fibre source and fibre level, as well for growing pigs as for fattening pigs. This results was confirmed by the findings of Van et al. (2012a, b).

The production of CH_4 in pig houses originates from the anaerobic degradation of organic matter by bacteria in the digestive tract of the animals and in the slurry. Increasing the fibre content of the diet was reported to promote the methanogenesis in both the pig's gut (Le Goff et al., 2002) and slurry (Jarret et al., 2012). In the current experiment, high fibre diet resulted in increased CH_4 emission from slurry by 18% and by 13% compared with low fibre diet, for growing pigs and fattening pigs, respectively. Pigs fed diet CC increased CH_4 emission from slurry by 12% and by 10% compared with pigs fed diet TFR, for growing pigs and fattening pigs, respectively.

The emission of CO_2 from slurry was significantly different between low and high fibre diets for growing pigs, but not for fattening pigs. The study of Philippe et al. (2015) showed that fibre content of the diet had no significant impact on CO_2 emissions, both for gestating sows and fattening pigs. Under laboratory conditions, Clark et al. (2005) obtained a 17% reduction of CO_2 emissions from slurry samples of pigs fed diet with 20% sugar beet pulp compared to 0% sugar beet pulp.

5. CONCLUSIONS

An increased fibre content in the diet decreased in the ADG and feed efficiency in both growing and fattening periods. In the growing period, the diet TFR had higher ADG than the diet CC, while in the fattening period, the diets containing different fibre sources had no effects on ADG.

In growing period, pigs fed LF diet had higher slurry pH and lower N excretion than pigs fed HF diet. Fibre source and fibre level had no effects on the characteristics of slurry and the excretion of slurry DM and P. Fibre source had no impact on the NH_3, H_2S and CO_2 emission, whereas CH_4 emission was higher for the diet CC than for the diet TFR. Increased dietary fibre level resulted in increased the CH_4 and CO_2 emission, and decreased NH_3 emission.

In fattening period, slurry chemical characteristics, N and P excretion were not affected by fibre source and fibre level. The fibre source did not affect the H_2S, CH_4 and CO_2 emission from pig slurry, while pigs fed diet TFR had greater the NH_3 emission from slurry than the pigs fed diet CC. The H_2S, and CO_2 emission was not affected by fibre level. Pigs fed HF diet showed higher CH_4 emission than pigs fed LF diet, while LF diet yielded greater NH_3 emission compared to that of HF diet.

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