Effect of pineapple pulps on nitrogen digestibility, nitrogen excretion and nitrogen losses from slurry during storage of growing-finishing pigs

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ASTRACT: An experiment was conducted to investigate the effect of pineapple pulps in diet for growing-finishing pigs with high level of non-starch polysaccharides (NSP) from by-products on nitrogen excretion and nitrogen losses from slurry during storage. Twelve commercial crossbred barrow of about 70 kg BW were randomly allotted to one of three diets. The control diet was formulated using tapioca as energy sources. In the other diets, tapioca was replaced by rice bran or pineapple pulps. The diets differed mainly in the amount and composition of NSP. After a 12-day adaptation period, urine and faces were collected separately in metabolism cages for 9 days. Urine and faces from the first four days were used to analyze the nitrogen partitioning. Urine and faces from the last 5 days were mixed as slurry. The slurry was sampled at the end of the collection period and again after 30 days storage, to analyze for nitrogen to calculate the losses. Increasing dietary NSP reduced urinary nitrogen and nitrogen losses from slurry during storage. The pigs fed the diet based on pineapple pulps excreted the most nitrogen via faces and the least nitrogen via urine. Nitrogen losses from slurry of pigs fed the pineapple pulps were from 39 to 68% lower than from other two diets. It is concluded that including NSP-rich by-products in the diet of growing-finishing pigs reduces urinary nitrogen excretion and nitrogen losses from slurry during storage.

Key words: nitrogen excretion, fiber, pineapple pulp, pig

1. INTRODUCTION

Pig production is not only a major protein source for human consumption but the manure from it is also important in supplying organic fertilizer. Traditionally, pigs are fed rice bran, cassava. While amount agricultural by-product such as beer by-product, pineapple pulps are also feed source for pig. It is well established that an increased supply for fermentable substrate to the microbes results in increased metabolic activity of the large intestinal micro flora of pigs (Morgan vµ Wittemore, 1988; Schulze et al, 1993). There is increasing evidence that excretion of nitrogen can be shifted from urine to faces when fermentable carbohydrate are available for microbial fermentation in the large intestine (Schulze, 1993). At the same time the total excretion of N may be at the same level. In research of Canh (1996) with fatterning pigs a clear effect of feed composition on the of the slurry and on ammonia volatilization was found.

In our research was to make one's choice for feed ingredients in traditional feed of households for intensive pig production, these alternatives could be the local agricultural by-products which contain high concentration of fermentable carbohydrate it may possible to improve both pig performance and manure quality, contribute reduce environmental pollution.

2. MATERIALS AND METHODS

- **Animal and housing**

A experiment was carried out on 12 commercial crossbred barrows (Vietnamese Mongcai x Lagre white), with initial BW of 70.5 kg were randomly allotted to one of three diets (table 1). From 65 kg onwards the animals were kept in groups and were fed treatment diets. When the animals reached 70 kg body weight, they were housed individually in a controlled room in metabolism cages that allowed the separated collection of urine and faces. The 21-day experimental period consisted of a 12-day adaptation period to allow the pigs to become accustomed to the cages and to the new diet and 9-day period during which urine and faces were collected.

Table 1. Ingredient composition of the experimental diets (g/kg diet)

Ingredients (as fed basic)	Tapioca	Rice bran	Pineapple pulp
Rice	230.0	230.0	230.0
Tapioca	511.0	341.5	342.5
Cane molasses	25.0	25.0	25.0
Groundnut extracted	125.0	125.0	125.0
Fish meal	78.0	48.0	42.0
Rice bran		200.0	
Pineapple pulp			200.0
Chalk	11.0	11.0	11.0
$CaHPO_4$	4.5	4.5	4.5
KH CO_3	2.5	2.0	7.0
Salt	3.0	3.0	3.0
Premix	10.0	10.0	10.0

- **Diets and feeding**

The ingredient compositions of experimental diets are given in table 1. The control diet was composed with rice and tapiocas basal energy sources. In the other two diets, tapioca was exchanged with the same amount (200 g/kg diet) of rice bran or pineapple pulp. Thus, the diets were similar, except for the contents of NSP-rich by-products and pineapple pulps. The diet based on pineapple pulp had the highest NSP content (18.92%), followed by the diets based on rice bran (12.88%) and the tapioca (6.95%) (table 2).

The pigs were fed 2 times per day. The ration was increased each day based on an estimated weight gain of 650 g/day. Feed was mixed with water before feeding (2 l/kg feed) and provided in two equal meals per day. Water was given ad libitum through a drinking nipple at the font of each metabolism cage.

Table 2: Chemical composition of experimental diets

Composition (as fed basic)	Tapioca	Rice bran	Pineapple pulp
NE, (kcal/kg)	2310	2316	2205
Crude protein (%)	12.70	12.48	12.06
Crude fat (%)	2.57	4.58	3.18
NSP (%)	6.95	12.88	18.92
Cellulose (%)	2.47	3.02	5.38
NDF (%)	2.61	4.82	7.05
ADF (%)	1.24	3.27	5.18
Lignin (%)	0.62	1.03	1.21
Water (%)	13.79	14.02	14.15
Crude ash (%)	4.93	5.45	4.92
Starch (%)	55.29	50.45	43.47
Sugar (%)	3.77	0.14	3.3
Phosphorus (%)	0.43	0.63	0.47
Sodium (%)	0.19	0.15	0.20
Calcium (%)	0.91	1.12	0.84
Potassium (%)	0.80	0.85	0.79
Chloride (%)	0.39	0.36	0.28
Magesium (%)	0.12	0.25	0.15
Copper (ppm)	3.6	3.0	3.2
dEB (meq/100g)	18.50	18.84	18.75

dEB = Dietary electrolyte balance (calculated as meq Na+ K-Cl)

- Chemical analysis

All samples were analyzed in duplicate. The diets and excreta were analyzed for DM, ash, crude fiber, crude fat and total N according to AOAC (1990). Urinary urea was determined by Neumann and Ziegenhorn (1977). Neutral detergent fiber (NDF) and acid detergent fiber were analyzed as described by Huisman (1990). The pH was measured by pH met Hanna directly submerged in the urine, in diluted faces (mixed with distilled water in a ratio 1:4) and in the slurry.

The urine and faces collected in the first 4 days were used for determining the nitrogen balance. They were stored at -20^{o}C until the nitrogen analyses were performed. To prevent nitrogen being lost by ammonia volatilization during this period, urine was collected in 50 ml 0f 25% sulphuric acid to keep the pH below pH 2. The urine and faces collected during the last 5 days, without adding acid to the urine, were used to make slurry. Urine and faces were collected twice a day, their pH was measured directly after collection, and they were then mixed to slurry in a plastic bucket. The buckets were stored uncovered in a room at ambient temperature (average about 25°C). After collection period the pooled slurry was sampled for chemical analyses. The buckets were kept for a further 30 days in the same room. After this storage period, the slurry was mixed and sampled for chemical analysis. The slurry was weighed at the beginning and the end of the storage period. The differences in total nitrogen of slurry at the start and the end of this 30-day storage period were used to calculate the nitrogen losses from slurry.

- **Statistical analysis**

Effect of the diet on average daily gain, nitrogen intake, nitrogen retention, nitrogen excretion and on excreta compositions and nitrogen losses were analyzed by SAS (1993). Factors of diets were analyzed according statistical model following

$$Y_{ij} = m + HLX_i + e_{ij}$$

Y_{ij} : Body weight, nitrogen intake, nitrogen in urine, nitrogen in faece, nitrogen in slurry of pig ordered n

m: Average

HLX_i: Fiber content in diet ordered (i=3)

e_{ij} : Residual error

3. RESULTS AND DISCUSSION

3.1 Nitrogen intake and nitrogen excretion

No health problems occurred during the experimental period. Table 3 shows that the animal daily BW gain, nitrogen intake, nitrogen excretion and nitrogen retension of the pigs on the different diets. Average body weight of pig of the diets at the end were not different. Daily weight gain of pigs were 657, 707, 692 g/day respectively the tapioca based, the rice bran based and the pineapple pulp based diets. Although the pigs fed rice bran had daily weight gain higher than from pigs on the other two diets, but the difference was not significant ($p>0.05$).

In our study the diets had a similar NE content but were formulated from different by-products and differed mainly in NSP content. The pineapple pulp based diet had the highest NSP content (18.92%), followed by the rice bran based diet (12.88%) and the tapioca based diet had the lowest NSP content (6.95%).

The nitrogen intake of the tapioca based diet was higher than the pineapple pulp diet ($p<0.05$). This can be explained by the crude protein content of the tapioca based diet had higher than the pineapple pulp diet. Total nitrogen excretion was effected by the diets. Pigs fed the tapioca and rice bran based diets had a higher in total nitrogen excretion ($p<0.05$).

Table 3: Weight gain, nitrogen intake, nitrogen excretion and retention of pig fed different diets

Variables	Tapioca	Rice	Pineapple	P^1

		bran	Pulp	
Number of pigs	4	4	4	
Initial BW[2] (kg)	70.5	71.2	70.7	NS
Final BW[3] (kg)	79.7	81.1	80.4	NS
Weight gain (g/day)	657	707	692	NS
N intake (g/day)	38.2[a]	36.6[ac]	34.7[bc]	*
Faecal N (g/day)	4.32[a]	6.05[b]	8.12[c]	***
Urinary N (g/day)	18.18[a]	15.55[b]	11.08[c]	***
Total N excretion (g/day)	22.5[a]	21.6[a]	19.2[b]	*
Urinary N: faecal N	4.21[a]	2.57[b]	1.36[c]	***
Apparent N digestibility (%)	88.7[a]	83.5[b]	76.6[c]	**
N retention, % of intake	41.0[a]	40.9[a]	44.7[b]	*

[1] Probability of a significant treatment effect, * p<0,05; ** p<0,01; *** p<0,001; NS = Not significant.
[2] The pigs were weighed four days before the collection period.
[3] The pigs were weighed one day after the collection period.
[a,b,c] Different letters in superscript indicate significant difference (p<0.05)

Faecal N was lowest in the tapioca based diet (4.32 g/day) and highest in the pineapple pulp diet (8.42 g/day) (p<0.001). Contrast, urinary N was highest in the tapioca based diet (18.18 g/day) and lowest in the pineapple pulp based diet (11.08 g/day) (p<0,001). The nitrogen excretion pattern, which is indicated by the ratio of urinary nitrogen to faces nitrogen, differed considerably between diets. The ratio of nitrogen excretion between urine and faces strongly decreased from the tapioca based diet (4.21) and the rice bran based diet (2.57) to the pineapple pulp based diet (1.36) (p<0.001). Pigs fed the pineapple pulp based diet excreted less nitrogen via urine than the pigs fed the rice bran based and the tapioca based diets, and excreted more nitrogen via faces. The results from this experiment support the concept that the amount of NSP in the diet can influence the nitrogen excretion pattern in pigs. Increasing the amount of NSP in the diet shifts nitrogen excretion via urine to faces.

Therefore, cellulose (crude fiber) seems to be the most important NSP component influencing the nitrogen excretion pattern. This is in agreement with findings by Mroz et al , 1993; Schulze et al, 1993, who found the highest faecal nitrogen excretion in pigs fed cellulose, and the lowest value was noted in pigs fed pectins. Fermentable carbohydrates serve as an energy source for micro flora in the large intestine of pigs, and urea secreted from the blood into the large intestine, serves as a nitrogen source (Low, 1985). When urea is transferred to the lumen of the large intestine, it is broken down to ammonia by bacterial urease and then used for microbial protein synthesis. The increase of NSP in the diet led to increased microbial activities in the hind gut. This protein is finally excreted in the faces.

The amount of urea secreted from blood into the large intestine increases with increased dietary fiber content (Low, 1985), resulting in a reduced urea content in the portal plasma (Malmlof, 1985). The synthesis of microbial protein causes less ammonia to be reabsorbed from the colon. As a result nitrogen excretion shifts from urine to faces. As a result, apparent nitrogen digestibility was highest in pigs fed the tapioca based diet (88.7%) and lowest in pigs fed the pineapple pulp base diet (76.6%) (p<0.05%).

When comparing the diets with respect to their nitrogen balance it is shown from table 3 that nitrogen retention is highest for the pineapple pulp diet (44.7%) (p<0.05). The other diets gave similar nitrogen retention.

3.2 Amount, pH and composition of urine and faces

The chemical composition of urine and faces from pigs fed the different diets is shown in table 4. The mean amount of faces of the pigs were 422 g/day, 622 g/day, 879 g/day, respectively for the tapioca based, rice bran based and the pineapple pulp based diets. The pineapple pulp based diet gave the largest amount of faces, followed by the rice bran based and lowest in the tapioca based diet (p<0.001). The amount of faces is related to NSP content in the diet. NSP content was highest in the pineapple pulp based diet (table 2). However, the amount was negatively related to the dry matter content of the faces. So, large amount of faces were partly caused by a higher content of water. It is evident that NSP may stimulate considerable additional secretion of water into the gut, and faces have a very high bacterial content, bacterial cells themselves are approximately 80% water Low, 1989).

The pigs fed the pineapple pulp based diet produced less urine than in the pigs fed the rice bran and tapioca based diets (p<0.001). So addition of fiber to the diet caused a major increase in the volume of water passing into and out of the large intestine. Total nitrogen concentration of faces and urine were lowest in the pineapple pulp based diet, and were the same in the tapioca and rice bran based diets (p<0.01). Total nitrogen concentration of urine were lower in the pineapple pulp based diet, causing fermentable carbohydrates are included in the diet more nitrogen will be excreted via faces in the form of bacterial protein and less via the urine in the form of urea (Mroz et al, 1993; Canh et al, 1997).

Table 4: Amount, pH and composition of faces and urine from pigs fed different diets

Component	Tapioca (n=4)	Rice Bran (n=4)	Pineapple Pulp (n=4)	P[1]
Amount (g/day):				
Urine	4247^{a}	3783^{a}	3028^{b}	***
Faces	422^{a}	622^{b}	879^{c}	***
Total N (g/kg):				
Urine	4.28^{a}	4.11^{a}	3.56^{b}	**
Faces	10.24^{a}	9.73^{a}	8.23^{b}	**
pH:				

Urine Faces	7.62 7.95[a]	7.51 7.73[a]	7.45 7.18[b]	NS **
Faecal CF (g/kg)	66.8[a]	72.8[b]	76.6[b]	**
Urin. urea (mmol/l)	136.7[a]	117.5[b]	102.3[b]	***
Tot. urinary urea (mmol/day)	580.5[a]	444.5[b]	309.8[c]	***

[1] Probability of a significant treatment effect, * p<0,05; ** p<0,01; *** p<0,001; NS = Not significant.

[a,b,c] Different letters in superscript indicate significant difference (p<0.05)

The urinary urea content was highest in the pigs fed the tapioca based diet, followed in the pigs fed the rice bran based diet and lowest in the pigs fed the pineapple pulp based diet (p<0.01). The pigs fed the pineapple pulp based diet excreted from 134.7-228.3 mmol/day (or 30 – 42%) less urea in urine than pigs on the other two diets. Causing fermentable carbohydrates are included in the diet more nitrogen will be excreted via faces in the form of bacterial protein and less via the urine in the form of urea (Schulze et al, 1995; Canh et al, 1997).

The pH of urine was not significantly different between diets (p>0.05). The pH of faces was lowest in the pineapple pulp based diet (P<0.01), it was not significantly different between the rice bran based diet and the tapioca based diet. The pH of faces from pigs fed the pineapple pulp based diet was 0.55 to 0.77 units lower than the pH of faces from the pigs fed other diets. The present results demonstrated that the NSP content of the diet affected the pH of faces. The pH of faces was lower in pigs fed an NSP-rich in the pineapple pulp diet than in pigs fed the diets with a low NSP content.

According to Sommer and Husted (1995), volatile fatty acids (VFA) and carbonate contents are important factors influencing the pH of faces. VFA are mainly produced from faces by microbial degradation of dietary fiber.

3.3 The chemical composition of slurry and nitrogen loss from slurry during storage

The composition of slurry at d 1and d 30 and nitrogen loss from slurry during storage is given in table 5.

Table 5: Composition of slurry at d 1 and d 30 and N loss from slurry during storage

Components	Tapioca (n=4)	Rice Bran (n=4)	Pineapple Pulp (n=4)	P
Day 1				
Amount[1], kg	22.34	21.02	19.53	NS
DM, g/kg	77.72[a.]	84.7[a]	96.8[b]	**
Total N, g/kg	5.37	5.51	5.62	NS
pH	794[a]	7.82[a]	7.21[b]	**

Day 30				
Amount[1], kg	15.19	14.65	13.86	NS
DM, g/kg	106.31[a]	120.15[b]	138.63[c]	***
Total N, g/kg	6.62[a]	7.18[b]	7.41[b]	**
pH	7.85[a]	7.79[a]	7.12[b]	***
N loss (%)[2]	16.20[a]	9.21[b]	6.32[c]	***

* p<0,05; ** P<0,01; *** P<0,001; NS = Not significant;

[1] Amount of 5 collection days

[2] Calculated by comparing the total N of slurry between day 30 and day 1

[a,b,c] Different letters in superscript indicate significant difference (p<0.05)

Table 5 shown that dry matter content of slurry at d 1 and d 30 were significant between diets. The dry matter content of slurry was highest in pigs fed the pineapple pulp based diet and lowest in the tapioca based diet (p<0.01). The dry matter content of slurry increased during storage, causing by water evaporated. Total nitrogen concentration of the slurry at d 1 was not significantly different between diets (p>0.05). Total nitrogen concentration of the slurry after 30 days storage was lower in the tapioca based diet (p<0.01), it was the same in the rice bran based diet and the pineapple pulp based diet. The pH of slurry from pigs fed the pineapple pulp based diet was 0.6 to 0.7 units lower than the pH of slurry from the pigs fed other diets P<0.001). Total nitrogen losses from slurry during the 30 d storage was different between diets (p<0.001). The nitrogen losses from slurry for the pineapple pulp based diet was 39 to 68% lower than for the rice bran based and the tapioca based diets. According to Canh et al (1997) which have shown that fermentable carbohydrates in the diet can influence the ammonia volatilization from pig slurry during storage. The main part of ammonia volatilization originates from the urea in urine (Aarnink et al, 1993). Nitrogen losses from the slurry only occurred by ammonia volatilization from the surface of the slurry. Urea is converted into ammonia and carbon dioxide by urease present in faces. Fermentable carbohydrates are included in the diet more nitrogen will be excreted via faces in the form of bacterial protein and less via the urine in the form of urea (Canh et al, 1997). Increasing the amount of NSP in the diet caused nitrogen excretion to shift from urine to faces. This resulted in a reduction of urinary urea content, and consequently, reduced the ammonium content of slurry (Schulze et al, 1993; Canh et al, 1997). Urea is converted into ammonia more quick than microbial protein converted into ammonia. In this study, VFA formation and the reduction of slurry ammonia probably caused the low pH of slurry from pigs fed NSP-rich diets. A lower ammonium concentration and a lower pH of slurry reduced the losses of nitrogen through evaporation.

4. CONCLUSION

Including non-starch polysaccharides rich by-products in the diet of pigs shifts nitrogen excretion from the volatilisable form in urine to the less accessible protein form in the faces. Non-starch polysaccharides also lower the pH of slurry, consequently there are clearly reduced nitrogen losses from slurry during storage. Such an approach may be an economical way of improving the quality of fertilizer from pig farming and of reducing the environmental impact of pig production.

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