Effect on Nutrient Digestibility and Nitrogen Balance in Grower Pigs Fed Three Forms of Blended Cassava Roots

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) can substitute for wheat and maize but is constrained by low protein, amino acid imbalance, high fiber and hydrogen cyanide content. This study examined the nutritional value of different forms of processed cassava as a substitute for wheat in grower pig diets. Apparent Total Tract Digestibility (ATTD) and Nitrogen Balance were estimated in grower pigs fed three cassava based test diets compared to a commercial Pig Grower feed (STDPG) as control using a 4x4 Latin Square design. The trial used four (Landrace x Large White) x Duroc male castrate pigs (28.0±0.8kg), housed in metabolic crates in an open sided shed over a 32 d trial period. The test diets consisted of 55% cassava (CA) comprising either boiled roots (CABR), ensiled roots (CAER), or milled roots (CAMR), blended with 45% DM of a formulated protein concentrate. Diets were fed *ad libitum* for a five day adaptation period followed by three days total collection of feces and urine. ATTD percentages of DM, NFE, calcium and energy for CABR45 (81.0, 82.9, 41.9, 88.7), CAER45 (82.5, 82.4, 51.1, 89.0) and CAMR45 (82.4, 89.9, 64.9, 89.1) were improved ($p<0.05$) compared to pigs fed the STDPG diet (68.7, 75.3, 2.6, 81.1). Ash, fat, protein and phosphorus (cv 45.8%) were similar to STDPG, but not fiber digestibility ($p=0.055$). N-retained as percentages of N-intake and N-digested were similar to STDPG ($p>0.05$). Regardless of the method of processing (boiled, ensiled or milled) cassava roots at 55% DM, blended with a complementary protein concentrate, improved the nutrient and energy digestibility, N-retained and growth (data not shown) of commercial genotype grower pigs. These blended cassava root diets are recommended but further performance and economic assessment is needed for small-scale farms producing local mixed genotype pigs.

Key Words: Cassava, Digestibility, Grower pigs, Nitrogen balance, Papua New Guinea

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) can substitute for wheat and maize on smallholder pig farms in tropical and sub-tropical countries due to its high starch content but its use is constrained by low protein, amino acid imbalance, high fiber and hydrogen cyanide (HCN) content. Cassavas grown in Papua New Guinea (PNG) are ‘sweet’ cultivars which are low in HCN (Bradbury and Holloway 1988). Suitable processing methods may eliminate anti-nutritive factors namely HCN, trypsin inhibitors, tannins, phytates and oxalates, which reduce palatability and digestibility of cassava (Teka et al. 2013). Cassava roots are very palatable fed fresh, boiled, as dry meal or ensiled feed and blending with a protein concentrate is a logical means to overcome the imbalance of essential amino acids. Boiling cassava roots requires continuous supply of fresh crop and fuel, and whereas drying cassava may be difficult under warm humid tropical conditions, ensiling fresh crop caters perfectly to processing and storage challenges. The feeding value of cassava fed to pigs farmed at small-scale have been reported when prepared by different processes, ingredients and formulations (e.g. Ospina et al. 1995; Phuc et al. 2000; An et al. 2004). In this paper we report the feeding value of a grower pig ration comprising local PNG yellow cassava roots blended at 55% DM content with 45% protein concentrate. Three cassava test diets, as boiled or ensiled or milled roots, were compared to commercial Pig Grower feed and tested for apparent total tract digestibility (ATTD) of nutrients and energy, and Nitrogen balance, when fed to commercial crossbred (Landrace x Large White) x Duroc grower pigs.

METHODS AND MATERIALS

The experiment was conducted at the PNG National Agricultural Research Institute (NARI) Livestock Station, Labu, outside Lae. The experiment design was 4x4 Latin Square with four diets as interchanged treatments fed to four grower pigs on four consecutive eight-day feeding periods. The test diets consisted of 55% cassava (CA) comprising either boiled roots (CABR), ensiled roots (CAER), or milled roots (CAMR), blended with 45% DM of a protein concentrate. The protein concentrate, Pig Conc.1, was based on wheat (48%), meat+fish+blood meal (28%), soybean (18%), tallow (4%) and formulated to supplement nutrient imbalances in cassava according to NRC (1998) and nutritional databases at Carey Nutrition Ltd. A commercial Pig Grower pellet (STDPG) based on wheat (91.2%) and meat meal, was used as the Control. Nutrient compositions of ingredients and treatments are shown in Table 1.

Table 1. Nutrient composition of the feed components and experimental treatments

Nutrients (%)	Components				Treatments			
	CABR	CAER	CAMR	PigConc1	CABR45	CAER45	CAMR45	STDPG
Dry matter	38.8	35.4	88.8	87.9	51.5	48.1	88.4	88.0
Ash	1.00	0.92	2.30	8.80	4.58	4.53	5.28	6.39
Fiber	0.61	0.56	1.40	4.10	2.21	2.19	2.64	5.64
Ether extract (fats)	0.26	0.24	0.60	4.40	2.16	2.14	2.34	3.78
Crude protein	0.74	0.68	1.70	32.9	15.4	15.4	15.9	16.5
NFE†	36.2	33.0	82.8	37.7	37.4	35.7	63.2	55.7
Total N	0.12	0.11	0.27	5.26	2.47	2.47	2.55	2.64
Lysine*	-	-	-	2.03	0.89	0.90	0.89	0.86
Methionine*	-	-	-	0.82	0.36	0.36	0.36	0.24
Meth+Cyst*	-	-	-	1.26	0.56	0.56	0.55	0.53
DE (MJ/kg)**	16.8	16.9	16.1	15.6	16.3	16.3	15.9	14.8
Lys:DE (g/MJ)***	-	-	-	-	0.57	0.57	0.58	0.60

*Calculated supply of lysine, methionine and Meth+Cyst from Pig Conc.1 as the major source of all essential amino acids.
**Calculated values using proximate data and the formula DE (kCal) = 4,151 - (122 x %Ash) + (23 x % CP) + (38 x %EE) – (64 x %CF), where R^2 = 0.89 and ME (kCal) = DE x (1.003 – (0.0021 x % CP), where R^2 = 0.48 (Noblet and Perez, 1993).
***Ratios calculated using the respective nutrient and energy values in this table.
† NFE is Nitrogen free extracts, a calculated estimate of carbohydrate content.

Four commercial crossbred (Landrace x Large White) x Duroc grower pigs were placed into metabolic cages at nine weeks-of-age and 28.0±0.8 kg bodyweight. Cages were equipped with trays for separation of feces and urine. Each feeding period included five days for adaptation to the test diets and three days feeding for collection of feces and urine. Feed was offered *ad libitum* (remaining feed weighed as refusal) and clean piped water was available at all times. Pigs were managed according to the animal welfare guidelines prescribed the University of Adelaide Animal Ethics Committee Approval Number 0000016426.

Total fresh feces were weighed, oven dried (Labec®, 105°C) and milled. Urine was collected over 24 hours. Urine and oven-dried feces samples were pooled for each period and duplicate samples stored at <0°C until analysis. Chemical tests were completed at the National Analytical and Testing Services Laboratory Ltd (Lae, PNG). Dry matter, ash, fat, protein and urine-N (by modified Kjeldahl), Ca and Total P were analyzed by AOAC (1990) methods.

Nitrogen Free Extract was calculated. Lysine, Methionine and Methionine-Cystine were estimated from Pig Conc.1, assumed to be the major source of amino acids. Data were collated in MS Excel and ANOVA conducted using GenStat 15th Edition (VSN Ltd).

RESULTS AND DISCUSSION

Dry matter, fiber, Nitrogen-free extract (NFE), calcium and percentage energy digestibility were significantly different to the control diet STDPG (Table 2), but ash, fat, protein and phosphorus (data not shown) were similar for all diets (p>0.1).

Table 2. Apparent total tract digestibility in grower pigs fed blended cassava root diets

Digestibility (%)	Grand mean	Treatment means				sed	lsd	*F* pr.	cv%
		CABR45	CAER45	CAMR45	STDPG				
Dry matter	78.7	81.0^{a}	82.5^{a}	82.4^{a}	68.7^{b}	2.12	5.18	0.002	3.8
Ash	40.6	36.0	44.5	50.1	31.9	7.03	17.20	0.137	24.5
Fats	58.9	57.9	56.2	67.2	54.2	4.80	11.75	0.127	11.8
Fiber	28.0	21.7^{a}	20.8^{a}	31.0^{a,b}	38.5^{b}	5.24	13.46	0.055	26.5
Protein	75.7	73.1	75.8	75.9	78.0	2.13	5.22	0.258	4.0
NFE†	82.1	82.9^{a}	82.4^{a}	89.9^{b}	73.2^{c}	2.76	6.74	0.006	4.7
Energy	87.0	88.7^{a}	89.0^{a}	89.1^{a}	81.1^{b}	1.31	3.21	0.002	2.1

Means with different superscripts are significantly different at p<0.05.
† NFE is Nitrogen free extracts, a calculated estimate of carbohydrate content.

The three cassava diets were superior to STDPG in DM, NFE and calcium and percentage energy digestibility (p<0.05). Fiber digestibility was significantly better for the high DM diets STDPG and CAMR45 than the low DM diets CABR45 and CAER45 (p<0.05), but STDPG showed a significant (p<0.05) net loss of calcium (data not shown). There were no significant differences in N-intake, fecal-N losses, N-digested or urine-N losses (cv. 38.1%) (Table 3). Although urine-N loses were lower on the test diets the results showed higher variation (cv 38.1%). N-retained on the test diets was similar (p<0.05) to the control diet. N-retained as percentage of N-intake and N-digested did not indicate differences (p>0.05) between processing methods or between high and low DM content of cassava diets and the control Pig Grower feed.

Table 3. Nitrogen balance in grower pigs fed blended cassava root diets

N balance (g/d)	Grand mean	Treatment means				sed	lsd	*F* pr.	cv%
		CABR45	CAER45	CAMR45	STDPG				
Intake	54.4	59.2	47.3	52.4	58.6	4.60	11.25	0.116	12.0
Feces	13.0	15.3	11.4	12.4	13.0	1.32	3.24	0.108	14.4
Digested	41.3	43.9	35.9	39.9	45.6	3.93	9.61	0.162	13.4
Urine	17.3	18.0	15.8	16.1	19.5	4.67	11.43	0.839	38.1
Retained	27.0	29.9	25.9	24.6	27.6	1.88	4.60	0.119	9.8
Retention as % of:									
N-intake	48.9	50.0	56.0	44.3	45.1	4.89	11.96	0.163	14.1
N-digested	64.7	68.3	74.7	58.4	57.4	6.85	16.75	0.121	15.0

Means with different superscripts are significantly different at p<0.05.

Nutrient digestibility of cassava root diets was lower than reported by Ospina et al (1995) and Phuc et al (2000). Two Lysine levels used by Ospina et al (1995) were similar to this work. Ospina et al (1995) fed soybean protein concentrate at graded levels to pigs (40-55kg BW) of similar genotype, whereas, our protein concentrate was wheat based, with only 18% soybean meal, and 28% animal protein sources. The regression estimates for organic matter (OM), CP and fat digestibility were higher for cassava diets fed *ad libitum* to pigs (30 kg BW) when soybean was replaced by graded levels of cassava leaf meal/ensiled as protein source (Phuc et al., 2000). However, our test diets were comparable to those of An et al (2004) who fed Large White x Mong Cai pigs (25kg BW) cassava meal at 59% and 64% of DM with sweet potato vines fresh, dried or ensiled as sole protein source and reported above 85% OM, 74% CP and 54% CF digestibility. While fiber digestibility in our cassava diets appeared lower, the clearly elevated carbohydrate (NFE) digestibility may have been the result of increased solubility of starch and non-starch polysaccharides through the processing techniques. Higher percentage of energy digested supports this suggestion. N-balance in cassava diets was similar to Pig Grower but the high variation of urine-N loses provided inconclusive evidence of any benefit. Importantly, N-retention was similar to the commercial feed with similar Lysine content and far improved against other literature values. In our cassava diets Lysine:DE ratios were equivalent to Pig Grower, though slightly below other recommended values for growers. However, growth rate and feed conversion (data not shown) were superior on the blended roots than the commercial feed. These results may be related to different root processing and the type or amount of protein ingredients. The significant improvement for DM digestibility of nutrients and energy and equal N-retention on our blended cassava root diets demonstrated their suitability to high performing genotypes. Clearly cassava roots blended at 55% of the diet improved the nutrient and energy utilization to grower pigs regardless of the mode of preparation. These blended cassava root diets are recommended but further performance and economic assessment is needed for small-scale farms producing local mixed genotype pigs.

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