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Characterization of carbohydrate fractions of cassava plant meal and its utilization by growing pigs

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Abstract

This research was carried out to evaluate the carbohydrate fractions of Cassava Plant Meal (CPM) and its utilization by growing pigs. CPM was prepared from milled sun-dried unpeeled cassava tuber plus leaves plus tender stems mixed in ratio 2.5:1. The proximate and carbohydrate fractions of CPM were determined. The CPM was included in the diets of growing pigs to replace maize at 0 %, 25 %, 50 %, 75 % and 100 % levels corresponding to T1, T2, T3, T4 and T5, respectively. Twenty growing crossbred (Large White x Hampshire) pigs (10 .0 $\pm$ 0.5 Kg) were used for the growth trial which lasted eight weeks. The proximate composition showed that CPM had 9.77 % crude protein, 5.35 % crude fibre, 3.38 % ether extract, 4.40 % ash and 65.70 % nitrogen free extract. The starch content of CPM was 1.91 % while the non-starch polysaccharides were 22.32 % for neutral detergent fibre, 10.96 % for acid detergent fibre, 4.15 % for lignin, 11.36 % for hemicelluloses and 6.81 % for cellulose. The final body weight, average daily gain and feed to gain ratio were higher in pigs fed all the CPM diets ($p > 0.05$). However, daily feed intake of the pigs increased ($p < 0.05$) with increasing levels of CPM in the diets. It can be concluded based on the findings in this study that CPM was low in starch, higher in soluble non starch than insoluble non starch polysaccharide with proximate values similar to that of maize. Also, CPM could replace maize completely in the diets of growing pigs without any deleterious effects on the growth response. The inclusion of CPM to replace maize could also lead to reduction in feed cost per kilogram gain of growing pigs.

Keywords: cassava plant meal; maize; growing pigs; non-starch polysaccharide

Introduction

Over the last few decades, the use of alternative feed resources particularly dietary energy sources in the diets of pigs have gained relevance. This may be due to the increasing demand for animal protein intake by the teeming human population at affordable cost (Pond and Lei, 2001; Zijlstra and Betranena, 2009). The suitability of cassava meal as an acceptable alternative energy feedstuff in the diets of different classes of pigs have been widely researched (Sonaiya *et al.,*1982; Sarwat *et al.,* 1988; Ravindran, 1990; Adesehinwa *et al.,* 2016) although composite Cassava Plant Meal (CPM) has been identified as a better alternative to cassava meal (Akinfala and Tewe, 2001).

Works by Akinfala and Tewe (2001); Akinfala *et al.* (2013) and Adeyemi and Akinfala (2018) have shown both the nutritive and cost-effective advantages of adding the under-utilized fractions (leaves and tender stems) of cassava to the diets of pigs. This combination was developed to attain a comparable minimum crude protein level (10 %) as maize. However, a major limitation preventing use of most alternative feedstuffs including CPM is the high crude fibre content mainly the

structural indigestible carbohydrate often designated as Non Starch Polysaccharide (NSP) (Pluske *et al.,* 2001; Zijltra and Betranena, 2009; Choct, 2015).

The NSP covers a broad range of polysaccharide molecules most importantly the non-alpha glucan of the plant cell wall. Studies (Bach Knudsen and Jorgensen, 2001; Lindberg, 2014; Choct, 2015) have indicated that the nutritional implications of high intake of NSP such as cellulose, hemicellulose, pectin and lignin in feedstuffs produced deleterious effects on nutrient digestibility, voluntary feed intake, feed efficiency and growth performance of pigs.

Previous works (Akinfala and Tewe, 2001; 2004; Akinfala *et al.,* 2013) on the utilization of CPM by growing pigs have produced conflicting results compared to maize-based diets. This may be due to the NSP fractions present in the CPM diets. The option to improve the nutritional value and utilization of CPM by growing pigs with the use of enzyme requires detailed description of its carbohydrate fractions. This research was undertaken to characterise the carbohydrate fractions of CPM and its effects on the performance of growing pigs.

Materials and methods

Collection and preparation of test ingredients

The cassava variety of Tropical *Manihot* Species (TMS) 30572 were purchased from a commercial farm within Obafemi Awolowo University Teaching and Research Farm, Ile-Ife while the cassava leaves were harvested from the plant stem and the tender stems were harvested at about 5 cm usually 6 - 7 nodes from the top of the plant. Following the procedure of Akinfala *et al.* (2002) the fresh tubers (unpeeled tubers) were washed and chopped into small pieces, sun dried on a concrete floor for about 2 – 3 days depending on the intensity of sunlight. Also, the fresh cassava leaves and tender stem were sun dried for about 2-3 days and 4-5 days, respectively after harvesting and were then milled separately using 0.3 mm mesh grinding machine. The cassava plant meal (CPM) was prepared by mixing dried unpeeled cassava tubers with the leaves and tender stems at the ratio of 2.5:1 of unpeeled tuber to leaves and tender stem while the ratio of leaves to tender stem was 5:1. These combinations were adapted from Akinfala *et al.* (2002).

Experimental animals, management and design

Twenty growing crossbred (Large White × Hampshire) pigs of average initial weight of 10.00 ± 0.57 were used for the experiment. There were four pigs per treatment and each served as replicate. Routine management practices were carried out on the animals on treatment basis. Feed and water were supplied *ad libitum* throughout the experimental duration. The experiment lasted eight weeks and the experimental design was completely randomized.

Experimental diets

Five experimental diets were formulated. Diet T1 was maize based and served as the control. Diets T2, T3, T4 and T5 had 25 %, 50 %, 75 % and 100 % of maize in diet T1 replaced with cassava plant meal (CPM) as shown in Table 1.

Table 1: Composition of experimental diets

Ingredients	Diets				
	T1	T2	T3	T4	T5
Maize	45	33.75	22.50	11.25	-
Cassava plant meal	-	11.25	22.50	33.75	45.00
Soybean meal	8.00	8.00	8.00	8.00	8.00
Palm kernel cake	25.00	25.00	25.00	25.00	25.00
Fish meal	2.00	2.00	2.00	2.00	2.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Oyster shell	3.00	3.00	3.00	3.00	3.00
*Premix (Vitamin-Mineral)	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
*Metabolizable energy (Kcal/Kg)	3210.03	3193.58	3135.29	3085.34	3001.50
Crude protein (%)	20.55	20.44	20.33	20.22	20.10
Crude fibre (%)	5.20	5.53	5.86	6.20	6.52

**Premix (Vitamin/mineral): vitamin A 10,000,000 IU; vitamin D 32,000,000 IU; vitamin E 8,000 IU; vitamin K 2,000 mg; vitamin B1 2,000 mg; vitamin B2 5,500 mg; vitamin B61,200 mg; vitamin B12 12 mg; biotin 30 mg; folic acid 600 mg; niacin 10,000 mg; pantoth enic acid 7,000 mg; choline chloride 500,000mg; vitamin C 10,000 mg; iron 60,000 mg; Mn 80,000 mg; Cu 800 mg; Zn 50,000 mg; iodine 2,000 mg; cobalt 450 mg; selenium 100 mg; Mg 100,000 mg; anti-oxidant 6,000 mg.*

Proximate, carbohydrate fractions and statistical analyses

The proximate analysis of CPM and diets was carried out following the procedure of AOAC (2005). The insoluble carbohydrate fractions of the cassava plant meal were analysed by methods outlined by Van Soest *et al.* (1991). All data obtained were analysed using Analysis of Variance (SAS 9.1) and means were separated using Duncan Multiple Range Test at 5% level of significance.

Results

Results of proximate composition and carbohydrate fractions of Cassava Plant Meal (CPM) are summarized in Table 2.

Table 2: Proximate content and carbohydrate fractions of cassava plant meal (CPM)

Parameters (%)	CPM
Dry matter (DM)	88.63
Crude Protein (CP)	9.77
Crude Fibre (CF)	5.38
Ash	4.40
Ether Extract (EE)	3.38
Nitrogen Free Extract (NFE)	65.70
Starch	1.91
Non-starch	
Neutral detergent fibre	22.32
Acid detergent fibre	10.96
Lignin	4.15
Hemicellulose	11.36
Cellulose	6.81
Insoluble NSP	10.96
Soluble NSP	11.36
Total NSP	22.32

CPM: Cassava plant meal

The proximate composition of experimental diets is shown in Table 3. The crude protein content ranged from 18.98 % to 20.41 % with T5 having the highest and T1 had the lowest. Similar trend was found with crude fibre and ash contents of the experimental diets. Increasing levels of cassava plant meal in the diets produced increasing crude protein, fibre and ash contents across dietary treatments. However, the ether extract and nitrogen free extract decreased across dietary treatments with increased inclusion of cassava plant meal to replace maize in the diets. In either case, T5 had the least values for the ether extract (4.97 %) and nitrogen free extract (52.26 %) while T1 had the highest values (5.52 % and 56.42 %, respectively).

Table 3: Proximate composition of experimental diets

	Diets					
Proximate composition (%)	**T1**	**T2**	**T3**	**T4**	**T5**	**±SEM**
Dry matter (DM)	94.00	93.89	93.33	93.22	92.53	0.37
Crude Protein (CP)	18.98	19.37	19.55	19.99	20.41	0.20
Crude Fibre (CF)	6.50	6.52	6.60	6.88	7.05	0.07
Ash	5.58	6.17	6.78	7.05	7.94	0.29
Ether Extract (EE)	5.52	5.36	5.25	5.10	4.97	0.11
Nitrogen Free Extract (NFE)	56.42	55.97	55.15	54.20	52.26	0.53

There were no significant differences (p >0.05) in the average daily weight gain, feed conversion efficiency and feed cost per kilogram of growing pigs fed graded levels of cassava plant meal (Table 4). Pigs on diet T5 had the highest daily gain (0.32 Kg) while pigs on diets T1 and T4 had the least (0.30 Kg). Pigs on T3 gave the best feed efficiency (2.52) while pigs on T2 and T5 had the least (2.70) feed conversion efficiency. Significant differences (p <0.05) existed for the average daily feed intake, feed cost per kilogram weight gain and total cost of feeding across dietary treatments. Pigs on T5 had the highest average daily feed intake (0.83 Kg) while pigs on maize diet (T1) which served as control had the least value (0.74 Kg). Pigs on T5 gave the lowest cost of feeding per kilogram weight gain (N 223.00) while T2 had the highest value (N 245.97).

Table 4: Growth performance and cost benefit ratio of growing pigs fed experimental diets

	Diets					
Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**±SEM**
Initial weight (Kg)	10.00	9.88	9.88	10.00	10.00	0.32
Final weight (Kg)	26.88	27.00	27.50	27.00	28.00	0.89
Average daily weight gain (Kg)	0.30	0.31	0.31	0.30	0.32	0.01
Average daily feed intake (Kg)	0.74^{b}	0.79^{ab}	0.79^{ab}	0.80^{a}	0.83^{a}	0.01
Feed to gain ratio	2.53	2.70	2.52	2.67	2.70	0.12
Feed cost/Kg (₦)	93.80	91.10	88.17	85.50	82.55	2.23
Feed cost/Kg weight gain	237.31^{ab}	245.97^{a}	222.20^{c}	228.30^{bc}	223.00^{c}	3.22
Total cost of feeding (₦)	5253^{a}	5102^{ab}	4938^{bc}	4788^{bc}	4623^{c}	80.60

(□ = Nigerian currency, Naira) (1USD = □ 350)

a,b,c,d,e means in the same row having different superscripts differ at p <0.05;

SEM: Standard Error of Means

Discussion

The higher values obtained for the proximate composition (crude protein and ash) of CPM compared to the values reported in earlier studies by Akinfala *et al.* (2011) may be due to standardization of cassava tender stem to a length of 5 cm, usually 6-7 nodes, from the top of the plant. This length has been found to be lush and high in mineral. Similar studies (Akinfala *et al.,* 2002; Khajarern and Khajarern 2007; Iheukwumere *et al.,* 2008) have also shown that these cassava fractions (leaves and tender stems) are very rich in crude protein, fibre, ash and ether extract but low in energy. Lower values (4.72 % and 9.00 %) have been previously reported (Akinfala *et al.,* 2002; 2011) for crude fibre and protein contents of CPM and whole cassava plant meal, respectively. The variations observed in the values may be due to varietal differences, length and age at harvest of the different cassava components (tender stems and tubers).

The cassava plant meal used in this study had high contents of NSP with only very low starch content compared with the values reported in earlier studies by Akinfala *et al.* (2011) and Ogundeji (2018). The neutral detergent fibre (NDF) and lignin contents obtained in this study were lower compared to the values reported by Akinfala *et al.* (2011) and Ogundeji (2018) who characterized the nutrient contents of CPM for broiler and growing pig as well as laying birds, respectively. However, this study reported higher acid detergent fibre (ADF) fraction compared with the values obtained in the studies of Akinfala *et al.* (2011) while Ogundeji (2018) reported higher values of 44.54 %. The differences observed in the contents of NSP contained in these studies may be due to the incorporation of less lignified tender stems component into the CPM mix. Work by Adeoye *et al.* (2004) obtained higher value of 30.38 % for the NDF of CPM. Again the differences in the reported values may be due to the cassava variety used, mixing ratio of the CPM and the length (5cm usually 6 – 7 nodes from the top of the plant) at harvest of the cassava components which may have reduced the lignification. Also, CPM had high proportion of soluble fractions of NSP than the insoluble. The critical importance of soluble NSP as reported by Pluske *et al.* (2001) is a determinant of the nutritive value of feedstuffs for monogastrics. Soluble NSP have been found in studies by Ikegami *et al.* (1990); Classon and Bedford (1991) to contribute to increased digesta viscosity, bulk and viscosity of the intestinal contents as well as decrease the rate of diffusion of substrates and enzymes within the digestive tract thereby producing negative effects on nutrients digestibility.

The proximate components of the experimental diets increased with increasing inclusion of CPM. This may be due to the incorporation of nutrient-rich cassava fractions (leaves and tender stems) into the diets. The crude protein values fall within the range (18.0 % and 20.0 %) recommended by Olomu (2011) and Aduku (2012). Similarly, the crude fibre and nitrogen free extract followed the trend reported by Akinfala *et al.* (2013) who found that increased inclusion of cassava meal in the diets of growing pigs increased the crude fibre contents of the diets while the nitrogen free extract decreased.

The non-significant difference ($p > 0.05$) in the values obtained for the average daily weight gain of pigs fed experimental diets despite the varying fibre levels may be attributed to the processing technique of particle reduction used to enhance the nutritional value of the diets. This was similar to observations by Mavronichalis *et al.* (2000); Kim *et al.* (2005); Brufau *et al.* (2006); Len *et al.* (2009) and de Lange *et al.*

(2010) in pigs fed locally available resources of high fibre content. The authors found that the processing techniques (pelleting, reduction of particle size and enzymes supplementation) enhanced its nutritional value and utilization as well as overcome the shortcomings of poor nutritive value due to high fibre content and of other components in the feed.

Also, the average daily feed intake increased significantly (p <0.05) with increasing inclusion of fibre-rich proportion of cassava leaves and tender cassava stems present in the CPM mix. These cassava fractions have been identified to be low in energy as depicted by the decreasing NFE values in Table 3. This result supports the scientific evidence reported by Akinfala *et al.* (2002) that monogastric animals will eat more to satisfy their energy requirements. It also agreed with reports of Adesehinwa (2008) that pigs will increase their feed intake to compensate for decrease in energy and nutrient density of the diet. The significant (p <0.05) reduction in cost of production (feed cost) with increasing levels of CPM may be due to the higher cost per kilogram of maize against CPM (N 130 versus N 69.45). Similar findings were reported by Akinfala (1997) and Adesehinwa *et al.* (2016) who fed cassava peel-based diets to growing pigs and found reduction in cost of production.

Conclusion

It can be concluded based on the findings in this study that CPM was low in starch, higher in soluble non starch than insoluble non starch polysaccharide with proximate values similar to that of maize. Also, CPM could replace maize completely in the diets of growing pigs without any deleterious effects on the growth response. The inclusion of CPM to replace maize could also lead to reduction in feed cost per kilogram gain of growing pigs.

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