Nutrient characterization of cassava plant meal

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Abstract
The study assessed the nutrient profile in composite Cassava Plant Meal (CPM) with a view to enhancing its efficiency through bio-fortification. Three CPM products were developed from Tropical *Manihot* Species (TMS) 30572 harvested at 24 months. The sun-dried unpeeled cassava root meal, cassava leaf meal and tender cassava stem meal were mixed at ratios 2:1, 2.5:1 and 3:1 while the ratio of the leaves to tender stems was 5:1 across the three cassava plant meal products. The proximate composition, minerals, amino acids, vitamins and fatty acids contents of CPM and maize were determined. Results of proximate contents showed that CPM products had comparable crude protein and nitrogen free extract as maize. CPM products showed superiority (p <0.05) in calcium content over maize meal though maize meal was significantly higher (p <0.05) in phosphorus content compared to the three CPM products. There was significant difference (p <0.05) in the lysine, methionine, arginine, alanine, cysteine, serine and leucine contents of all CPM products and maize. Also, there was no significant difference (p >0.05) between CPM product 1 and maize meal for tryptophan, valine, proline and isoleucine. CPM products had significantly (p <0.05) higher values than maize in cholecalciferol, thiamine, niacin and riboflavin contents. In all analysed fatty acids contents, CPM products had significantly (p <0.05) higher values than maize with CPM product 1 showing superiority over other CPM products and maize. Based on the findings of this study, it can be concluded that CPM products had comparable nutrient profile as maize with CPM product 1 comparatively better in all evaluated nutrient profile.
Key words: Cassava plant meal products, maize, nutrients.

Introduction

Improving livestock productivity especially poultry and swine production require adequate supply of low-cost feeding ingredients. The cost of feeding has been reported to be 65 – 80 % of the total cost of production (Longe, 2006) with maize constituting 40 – 60 % of a balanced maize-soy based diet for poultry and swine. However, the seasonal feed deficit, ever rising cost of feeding ingredients and competition with human food consumption (Halimani *et al.,* 2007) have consistently driven efforts towards the use of alternative dietary energy feed resources for monogastrics (Morgan and Choct, 2016; Akinfala, 1997). One of such alternative dietary energy feedstuff is cassava. Cassava and its components have enjoyed widespread patronage as potential energy source for animal production in Nigeria. It is cheap, widely grown with a yearly tuber production of 59.5 million tons and grows at an annual rate of + 4.0 %; the largest in the world (FAOSTAT, 2017). However, after harvesting the value-giving component, substantial proportion of the co-products (leaves and tender stems) are allowed to rot on farms and homesteads (Akinfala and Tewe, 2004). The incorporation of these cassava fractions to form composite cassava plant meal (unpeeled cassava tuber meal + cassava leaves and tender cassava stem meal) had been shown by previous studies to enhance performance of pigs (Akinfala *et al.,* 2013; Adeyemi and Akinfala, 2018) and poultry (Akinfala *et al.,* 2002; Akinfala *et al.,* 2011). Similarly, studies have reported detailed information on the efficiency and nutrient profile of cassava flour (Ngiki *et al.,* 2014; Nagib and Sousa, 2007) or leaves (Iyayi and Losel, 2001) or peels (Ngiki *et al.,* 2014; Iyayi and Losel, 2005) and its acceptability as energy source for livestock. Nevertheless, the detailed nutrient profile of CPM has not been widely documented. Detailed information on feed resource could support sustainable livestock production and offer wider feed options in livestock production system (FAO, 2018). The research was carried out to characterise the nutrients in cassava plant meal with a view to enhancing its efficiency through bio-fortification.

Materials and methods

Experimental location and preparation of test ingredients

The experiment was carried out at the Poultry Meat Laboratory of the Department of Animal Sciences Obafemi Awolowo University, Ile-Ife and the Laboratory of Animal Science, University of Ibadan, Ibadan. The cassava variety of Tropical *Manihot* Species (TMS) 30572 aged 24 months were purchased from a commercial farm at Ile-Ife. The roots were lifted and soil was shaken off the roots while the cassava leaves were harvested from the plant stem and the tender stems were harvested at 5 cm, usually 6 to 7 nodes from the top of the plant. All the cassava components were harvested between April and June 2017. The fresh roots (unpeeled cassava root) were washed and chopped into small pieces, sun-dried on a concrete floor for an average of 5 – 6 days depending on the intensity of the sunlight, milled with 3 mm sieve mesh and packed into sacks. Also, the fresh cassava leaves and tender stems were sun-dried for about 5-6 days and 9-10 days respectively after harvesting, milled and packed into separate sacks. The composite cassava plant meal products were mixed in line with the procedure of Akinfala *et al.* (2002) at three different ratios of 2:1, 2.5:1 and 3:1 represented as products 1, 2 and 3 respectively. The mixing ratio was in attempt to have comparable minimum crude protein content of 10 % as maize.

Nutrient determination

The nutrients determined in the cassava plant meal products include amino acids (essential and non-essential amino acids), vitamins (fat and water soluble vitamins), minerals (calcium, phosphorus, sodium, chlorine, zinc, manganese and copper) and essential fatty acids (linoleic acid 18:2, linolenic acid 18:3 and arachidonic acid 20:4). The fat soluble vitamins were determined following the procedure outlined by Adams and Moss (1995). The amino acid profile was carried out using the spectrophotometric determination of Ninhydrin chemical reaction. Minerals (Ca, P, Na, Zn, Mg, Mn, Cu, K and Cl) and fatty acids were determined following the methods of AOAC (2005). Also, proximate composition was determined in line with the procedure outlined by AOAC (2005).

Results and discussion

The three cassava plant meal (CPM) products had comparable values with maize in the crude protein, ether and nitrogen free extracts (Table 1). Although, significant difference (p <0.05) exists in the values obtained for the crude fibre and ash with maize having the lowest values while CPM product 1 had the highest. The ash content of the CPM products decreases with increased inclusion of unpeeled cassava root meal in the mix.

Table 1: Proximate composition of maize and cassava plant meal products

		Cassava Plant Meal Products				
Proximate Composition (%)	**Maize**	**1**	**2**	**3**	**SEM**	***P***
Dry Matter (DM)	88.05	90.18	90.17	90.06	0.36	0.15
Crude Protein (CP)	10.38	12.62	12.25	12.51	0.56	0.24
Crude Fibre (CF)	2.57^d	8.05^a	4.69^c	6.81^b	0.79	0.01
Ash	2.82^c	6.69^a	6.53^a	6.15^b	0.60	0.01
Ether Extract (EE)	4.53	5.38	3.12	3.33	0.37	0.30
Nitrogen Free Extract	67.75	57.44	63.58	61.26	0.07	0.28

^{a,b,c,d} means in the same row having different superscripts differ at p <0.05; SEM: Standard Error of Means
ND = Not Determined
Product 1 contained sun dried unpeeled cassava tuber meal + cassava leaf meal + tender cassava stem meal mixed at a ratio of 2:1 while the ratio of the leaves to tender cassava stems was 5:1 while Products 2 and 3 contained the same components but mixed at ratios 2.5:1 and 3:1 respectively.

The mineral contents of maize and cassava plant meal is shown in Table 2. The CPM products have significantly (p <0.05) higher values than maize for calcium, magnesium, potassium, manganese and sodium. The values obtained for phosphorus content of CPM were lower than maize. The calcium and phosphorus contents of CPM increased significantly (p <0.05) across products 1 through 3. Lower calcium values (1.93 ppm and 0.28 ppm) were reported by Akinfala *et al.* (2011) who determined the mineral contents of CPM product 2 and maize. The minerals (zinc and copper) composition of CPM was comparable with maize. The variations observed in the mineral composition of CPM and maize may be due to variations in their ash and fibre contents.

Table 2: Mineral composition of cassava plant meal products

		Cassava plant meal products				
Minerals	**Maize**	**I**	**II**	**III**	**±SEM**	***P***
Calcium (%)	0.021[b]	0.269[a]	0.389[a]	0.417[a]	0.06	0.03
Magnesium (%)	0.115[c]	0.189[a]	0.182[a]	0.173[b]	0.02	0.032
Potassium (%)	0.316[b]	0.744[a]	0.781[a]	0.768[a]	0.76	0.01
Copper (g/Kg)	0.003	0.005	0.004	0.005	0.001	1.00
Manganese (g/Kg)	0.011[b]	0.060[a]	0.056[a]	0.058[a]	0.008	0.004
Sodium (g/Kg)	0.265[b]	0.371[a]	0.395[a]	0.386[a]	0.021	0.023
Phosphorus (%)	0. 237[a]	0.076[b]	0.089[b]	0.091[b]	0.033	0.029
Zinc (g/Kg)	0.063	0.061	0.059	0.061	0.001	0.81
Chlorine (%)	3.626[b]	2.376[b]	1.530[c]	5.125[a]	1.08	0.006

means having different superscript in a row differ significantly ($p < 0.05$)

Significant difference (p <0.05) exists in the amino acid contents (Tryptophan, Valine, Proline and Isoleucine) of maize and CPM (Table 3). The valine and isoleucine contents of CPM decrease across products 1 through 3 while proline content of the three CPM products increased with increasing levels of unpeeled cassava root meal. For other analysed amino acids (lysine, methionine, arginine, alanine, cysteine, serine, phenylalanine and leucine) contents, there were similarities in the values obtained for maize and CPM products. The increasing values obtained for arginine, cysteine and phenylalanine may be due to the increased proportions of these amino acids in the unpeeled cassava root meal.

Table 3: Amino acid composition of cassava plant meal products

		Cassava plant meal products				
Amino acids (%)	**Maize**	**I**	**II**	**III**	**±SEM**	**p value**
Lysine	0.63	0.61	0.47	0.55	0.03	0.35
Methionine	0.35	0.29	0.23	0.29	0.03	0.58
Arginine	0.87	0.79	0.89	0.92	0.03	0.32
Alanine	1.29	1.31	1.28	1.42	0.03	0.32
Tryptophan	2.16[a]	2.09[ab]	1.92[c]	2.12[a]	0.37	0.02
Cysteine	1.93	1.81	1.82	2.06	0.05	0.25
Valine	3.20[a]	3.10[a]	2.96[ab]	2.72[b]	0.08	0.04
Serine	1.66	1.51	1.61	1.55	0.03	0.15
Phenylalanine	2.53	2.42	2.42	2.49	0.03	0.55
Proline	1.42[a]	1.25[a]	1.30[bc]	1.39[b]	0.03	0.03
Isoleucine	4.09[a]	4.09[a]	3.80[b]	3.71[b]	0.07	0.01
Leucine	4.88	5.22	5.05	5.01	0.06	0.23

means having different superscript in a row differ significantly ($p < 0.05$)

The vitamin contents of CPM products decrease across products 1 through 3 with increased inclusion of unpeeled cassava root meal except for vitamin E (tocopherol). The maize meal showed superiority over CPM in vitamins A (retinol), E (tocopherol) and C (ascorbic acid). CPM products have significantly higher values of vitamins D (cholecalciferol), thiamine, niacin and riboflavin. The vitamin D contents of the three CPM product were 31.80 %, 27.32 % and 26.11 % better than maize. The decreasing trend observed in the vitamin (A, D, C, thiamine, niacin and riboflavin) contents of CPM products 1 through 3 may be due to the low contents of these vitamins in the unpeeled cassava root meal as compared to the leaves and tender stem meals. Similarly reports were found by Salvador *et al.* (2014) and Montaldo (1977) who evaluated the niacin and thiamine as well as riboflavin contents of cassava root meal and unpeeled cassava root meal respectively and obtained lower values.

Table 4: Vitamins composition of cassava plant meal products

Vitamins	Maize	Cassava plant meal products I	II	III	+SEM	p value
A (g/g)	911.67[a]	577.50[b]	355.83[c]	324.17[c]	50.24	<0.001
D (g/g)	443.33[c]	650.00[a]	610.00[b]	600.00[b]	23.88	<0.001
E (g/g)	350.00[a]	275.00[c]	283.33[bc]	295.00[b]	9.15	<0.001
C (g/ml)	3.06[a]	1.73[ab]	1.49[b]	1.69[ab]	0.29	0.012
Thiamin (mg/100g)	0.157[c]	0.270[a]	0.243[ab]	0.213[b]	0.13	0.002
Niacin (mg/100g)	1.467[b]	1.833[a]	1.700[a]	1.667[ab]	0.05	0.024
Riboflavin (mg/100g)	0.077[c]	0.130[a]	0.103[b]	0.093[bc]	0.01	0.024

means having different superscript in a row differ significantly (p <0.05)

Cassava plant meal products were superior to maize in all the measured essential fatty acids contents. CPM product 1 had significantly (p <0.05) higher values than products 2 and 3. The difference in the values may be due to variations in crude fibre and ether extract contents of the three products and maize.

Table 5: Essential fatty acid composition of cassava plant meal products

Fatty acid (%)	Maize	Cassava plant meal products I	II	III	+SEM	p value
Linoleic acid	1.04[c]	5.61[a]	3.92[b]	4.48[b]	0.59	0.004
Linolenic acid	0.07[c]	0.28[a]	0.20[b]	0.22[b]	0.03	0.001
Arachidonic acid	1.52[d]	6.09[a]	4.26[c]	4.87[b]	0.63	0.001

means having different superscript in a row differ significantly (p <0.05)

Conclusion and Recommendation

Based on the findings of this study, it can be concluded that cassava plant meal products had comparable nutrient profile as maize with CPM product 1 comparatively better in all evaluated nutrient profile. It is therefore recommended that CPM be supplemented with ample quantity of phosphorus to enhance desirable performance of livestock.

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