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Nutrient standardization and characterization of cassava plant meal

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Target audience: *Pig Farmers, Monogastric Animal Nutritionist*

Abstract

The study standardized and assessed the nutrient profile of composite Cassava Plant Meal (CPM) with a view to determining its suitability as feedstuff for livestock. Three CPM products were developed from cassava (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 CPM products. The tender cassava stem were harvested at 5 cm, 10 cm and 15 cm from top of the plant, unpeeled cassava root meal and leaf meal were analysed for proximate composition. The proximate composition, minerals, amino acids, vitamins and fatty acids of CPM products and maize were determined using standard chemical procedures. Results showed that cassava tender stem harvested at 5 cm had the best (P < 0.05) nutrient composition with highest crude protein (7.24 %). The proximate composition of cassava fractions differed significantly (P < 0.05). The proximate composition showed that CPM products had comparable (P > 0.05) crude protein and nitrogen free extract values as maize. CPM products showed superiority (P < 0.05) in calcium over maize meal though maize meal was significantly higher (P < 0.05) in phosphorus (0.237 %) compared to CPM products. The proline, valine, tryptophan and isoleucine amino acids differed significantly (P < 0.05) across the CPM products and maize. CPM products are significantly (P <0.05) higher in vitamins and fatty acids than maize. In conclusion, Cassava plant meal product 1 had comparable nutrient profile as maize and Cassava tender stem meal harvested at 5 cm from top of the plant be included in the products.

Key words: Cassava plant meal products, Maize, Nutrients.

Description of the Problem

The use of cassava and its by – products as replacement of maize for livestock feeding has been advocated by researchers (1). According to (2), Nigeria produced 55 million tonnes of cassava with leaf yield estimated at 12 million tonnes, 5.4 million tonnes of cassava peels and stem yield of 24.32 million tonnes per annum. Apart from the edible pulp of cassava, a substantial proportion are discarded at harvest and during processing for human food as cassava, by–products are usually left under – utilized in large quantities and often cause pollution to the environment (3, 4). Cassava root meal is deficient in protein, essential amino acids, carotene and other carotenoids hence there is need to fortify cassava with leaves and tender stem to take advantage of their high protein and bulkiness. This led to development of composite cassava plant meal (unpeeled tubers + tender stems + leaves) to replace maize in the diets of growing pigs (3, 5, 6 and 7).

The cassava plant meal reduced considerably the flour content by adding more of peels, leaves and tender stems, which are under-utilized in Nigeria (6). Available literature reports (4, 7, 15 and 20) showed variations and conflicting results regarding the nutrient composition of cassava plant meal. Nevertheless, information on the standardization of cassava plant meal products and detailed nutrient characterization has not been widely documented. Detailed information

on feed resource could support sustainable livestock production and offer wider feed options in livestock production system (8). The study standardized and characterised the nutrients in cassava plant meal with a view to determining its suitability as a feedstuff for all livestock species

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 Animal Science Laboratory, University of Ibadan, Ibadan. The cassava roots (TMS 30572) aged 24 months were purchased from a commercial farm around Ile –Ife. The cassava roots were harvested from the soil while the leaves were harvested from the cassava plant stem. The tender cassava stems were harvested at about 0 - 5 cm, 0 – 10 cm and 0 – 15 cm from the top of the plants usually 5 – 19 nodes from top of the plant constituting 4.17 – 20.85 % of the stem.

The fresh roots (unpeeled cassava root) were washed, 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 using a hammer milling machine with 0.20 mm sieve mesh at a commercial feed mill and packed in a sack bag. The fresh cassava leaves and tender stems were sun-dried for about 5-6 days and 9-10 days to a moisture content of about 7 – 8 % respectively after harvesting, milled using a rotatory fine grinder (made by Universal Process Engineer Pvt. Ltd, Nacharam, Indian) of the sieve size 0.01mm and packed separately into different sack bags.

Cassava Plant Meal Product Development

Three products were developed using the protocol of (9). Three Cassava plant meal (CPM) products were developed by mixing sundried unpeeled cassava root meal (UCRM) with the sun-dried cassava leaf meal and tender stem meal at a ratio of 2:1, 2.5:1 and 3:1 while the ratio of the leaves to tender stems was 5:1 for the products. The CPM product I contain 66.67 % UCRM, 27.78 % leaf meal and 5.63 % tender cassava stem meal; CPM product II contain 71.43 % UCRM, 23.80 % leaf meal and 4.77 % tender cassava stem meal while CPM product III contained 75 % Cassava root meal, 20.83 % leaf meal and 4.17 % tender cassava stem meal.

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 included 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).

Fatty Acid Determination: The fat and fatty acids are extracted by hydrolytic method from feedstuffs followed by extraction into ether, then methylated to fatty acid methyl esters (FAMEs). The FAMEs quantity was measured using gas chromatography procedure of (10) procedure.

Determination of Minerals

The concentrations of calcium, iron, zinc, magnesium, manganese and copper were determined according to the methods of (10). 2 g of sample was ashed at 600 ^{0}C in a Gallenkamp muffle furnace for 3 hrs, and cooled to room temperature in a desiccator. The residue was extracted in a crucible with 5ml hydrochloric acid (HCl) for 30 minutes, filtered with ash-free filter paper into a 100 ml volumetric flask and made to 100 ml with

distilled water. The concentrations of each element were determined by atomic absorption spectrophotometer. The phosphorus was estimated using Stannous-chloride method. Ammonium molybdate and stannous chloride was added to 5 ml of the filtrate and left for 20 minutes. The absorbances were read on UV spectrophotometer at 600 nm. The concentrations of phosphorous of sample in ppm were determined comparing the absorbance with that from a standard curved of pure phosphorous concentration. Other mineral elements were determined after wet digestion with a mixture of nitric acid, sulphuric and HCl using Atomic Absorption Spectrophotometer (AAS Buch Scientific, East Norwalk, Model SP9).

Concentration was determined by the following:

Phosphorous (ppm) = Absorption of sample (nm) /Slope of standard curve

Hydrocyanide Determination

The method used was alkaline picrate method modified by (11). Sample of 5 g each was added into 50 ml distilled water in a conical flask and allowed to stand overnight. 1 ml of the sample filtrate in a corked test tube was added to 4 ml of alkaline picrate and incubated in a water bath for 5 minutes. The absorbance of the samples were taken at 490 mm and that of a blank containing 1 ml distilled water and 4 ml alkaline picrate solution before the preparation of cyanide standard curve but there was no colour change in any of the corked test tube containing the samples which is the indication of absence of cyanide in the sample i.e. colour changed from yellow to reddish brown after incubation for 5 min in a water bath when sample contain cyanides in them.

Amino Acid determination: The amino acid profile of the products and maize was carried out using the spectrophotometric determination of amino acids using Ninhydrin chemical reaction.

Reagents: 0.1 mol/l standard solutions of different amino acids (i.e Alanine, Aspartic acid, Leucine, Isoleucine, Lysine, Methionine, Glycine, Threonine, Glutamic acid and other amino acids at P^H 5.5, Methyl cellosolve (ethyleneglycolmonomethyl), 50 % Ethanol (V/V), Hydrindantin, Ninhydrin reagent (which was prepared by dissolving 0.8 g of Ninhydrin and 0.12 g of hydindantin in 30 ml of methyl cellosolve. 10 ml of acetate buffer was prepared fresh and stored in a brown bottle) and 6MHCl.

Preparation of Sample by Hydrolysis

1g of well ground sample was weighed into a stoppered 250 ml conical flask, 100 ml of 6MHCl was added to the sample stoppered and heat in an oven or incubated for 16 hours to hydrolyse the sample. The mixture obtained was filtered through a double layer Whatman No 42 filter paper into another 250 ml conical flask and stoppered. The hydrolysate obtained was stored at – 4 ^oC after analysis.

Determination: 2 ml of the above hydrolysate was pipetted into a 30 ml test tube. 10 ml of buffered ninhydrin reagent added, heated in a boiling water bath for 15 minute, cool to room temperature and 3 ml of 50 % ethanol was added immediately.

0.5µg/ml working standard amino acids were prepared from each standard solution of amino acids to get the gradient factor from the calibration curve for each amino acid. The working standards were heated with the buffered ninhydrin reagent as done with the sample hydrolysate above. The absorbance or transmittance of sample buffered heated hydrolysate and working standards were measured at the wavelength of colour developed by each amino acids using a spectrophotometer model spectrumlab 23A.

% Amino acid (any one)

$$= \frac{\text{Absorbance of sample} \times \text{Gradient factor} \times \text{Dilution factor}}{10{,}000} \times \frac{100}{1} \quad \text{(iii)}$$

Statistical Analysis

Data obtained was statically analysed using one – way analysis of variance (ANOVA) and the means were separated using (12).

Results and Discussion

Proximate composition of different tender cassava stem lengths

The results of proximate composition of different tender cassava stem lengths is shown in Table 1.

The dry matter and ether extract ($P > 0.05$) of tender cassava stem length (TCSL) increased with an increase in length across the different TCSLs except for ash and Nitrogen free Extract. The crude fibre and crude protein differed significantly ($P < 0.05$) across the TCSLs and increased with increase in stem length. The 15 cm length had the significantly ($P < 0.05$) highest crude fibre (10.62 %). The variation in crude fibre may be due to the differences in their level of lignification due to variations in the maturity of the cassava plant stems. Inclusion of 15 cm TCSL in the product may increase the crude fibre, bulkiness and lower the metabolisable energy of the products resulting in increased feed intake, viscosity and lower digestibility of nutrients in the feedstuff fed to the animals. The 5 cm length had the significantly ($P < 0.05$) highest CP (7.24 %). The differences obtained may be due to the variations in degree of lushness of the stem length. Inclusion of tender cassava stem lengths above 5 cm may reduce the nutrient intake and lower its digestibility due to their higher crude fibre content (13).

Table 1: Proximate composition of different tender cassava stem lengths

Parameters (%)	Cassava Tender Stem Length				
	5 cm	10 cm	15 cm	SEM (±)	P value
Dry Matter	90.52	90.65	90.68	0.05	0.35
Crude Fibre	3.21^{c}	6.36^{b}	10.62^{a}	1.22	0.01
Crude Protein	7.24^{a}	6.34^{a}	3.72^{b}	0.81	0.01
Ether Extract	0.86	1.19	1.13	0.15	0.25
Ash	9.10	9.08	7.02	0.67	0.44
Nitrogen Free Extract	70.11	67.69	68.20	1.60	0.78

Means bearing different superscript in a row differ significantly (P<0.05)

Proximate composition of cassava fractions

The result of proximate composition of different cassava fractions is shown in Table 2. There were significant differences ($P < 0.05$) across cassava leaf meal, unpeeled cassava root meal (UCRM) and tender cassava stem meal for dry matter, ether extract, ash, crude fibre, crude protein and Nitrogen free extract.

The cassava leaf meal had the highest ($P < 0.05$) dry matter (91.58%). The differences in dry matter may be due to variations in physiology of the different cassava plant fractions, storage and cassava cultivars. The tender cassava stem meal had the least ($P < 0.05$) crude fibre (3.21%). The crude fibre of UCRM (6.36 %) was higher compared to value (4.05 %) reported by (14). The variations may be due to differences in age and variety of the cassava plant. Inclusion of UCRM in diet may reduce the metabolizable energy and crude protein digestibility due to its ability to become more viscous hence, longer transit time in the gut of the animal. The cassava leaf meal had the highest ($P < 0.05$) ether extract (5.28 %), crude protein (32.49 %) and ash (9.10 %). The highest ($P < 0.05$) leaf meal ash over other

cassava fractions agreed with the findings of (15) that inclusion of cassava leaf meal in the diets of animal could contribute higher proportion of mineral to the diets thereby increasing the mineral profile. Aletor (15) reported higher (P < 0.05) crude protein (41.7 %) of cassava leaf meal. He observed that crude protein and amino acid profile of cassava leaf meal are of good quality containing high lysine and low sulphur containing amino acid such as methionine and compared with that of soybean meal used as protein source in diets of animal. The nitrogen free extract (NFE) value ranged from 42.43 % to 75.49 %. The UCRM had the highest value (75.49 %).

Table 2: Proximate composition of cassava fractions

Parameters (%)	UCRM	TCSM	Leaf meal	SEM (±)	P value
Dry Matter	89.40^{b}	90.52^{a}	91.58^{a}	0.55	0.01
Crude Fibre	6.36^{a}	3.21^{b}	6.09^{a}	1.22	0.04
Crude Protein	4.75^{b}	7.24^{b}	32.49^{a}	0.64	0.02
Ether Extract	1.51^{b}	0.86^{b}	5.28^{a}	0.55	0.03
Ash	2.71^{c}	8.64^{b}	9.10^{a}	0.99	0.01
Nitrogen Free Extract	75.49^{a}	70.57^{a}	38.62^{c}	5.86	0.04

Means bearing different superscript in a row differ significantly (P<0.05)

Proximate composition of maize and cassava plant meal products

The result of proximate composition of maize and cassava plant meal (CPM) products is shown in Table 3**.** The dry matter (DM), ether extract (EE), ash, Nitrogen free extract (NFE), hydrocyanide (HCN) and Metabolisable energy (ME) differed significantly (P < 0.05) across the CPM products and maize. The differences (P < 0.05) in DM may be due to variations in the storage and variety (16). Substitution of maize with CPM products in diet might increase DM apparent digestibility. Substitution of maize with CPM products might improve fat composition of the animal tissues and DM digestibility due to their higher (P < 0.05) ether extract. The high ash (P < 0.05) of CPM products than maize may improve mineral balance of the diet and osmoregulation of the body system when included in diet.

The standardization of cassava tender stem at 5cm from top of the plant increased the crude protein of CPM products due to the tenderness, low fibre, less lignification and high crude protein of the leaves and tender stem (17) hence Substitution of maize with CPM products in diet of monogastric might increase the crude protein of the diet. The variations obtained in NFE values agreed with findings of (18) that variations in nutrient composition of cassava might be due to differences in the nutrient profile of cassava plant parts (or its combinations), variety and environmental conditions.

The DM, ME, ash, HCN and crude fiber of the CPM products increased with increase UCRM of the products. Substitution of maize with CPM products in the diets of pigs might reduce metabolisable energy of the diet. The differences may be due to variations in the nutrient profile and crude fiber content of diets (19).

The lower cyanide of the CPM products obtained may be due to proper processing which agreed with the findings of (18) that cyanide levels of less than 50 ppm can be obtained in sun – dried samples through proper processing and safe for livestock consumption (21). The metabolisable energy and hydrocyanide increased (P < 0.05) with increase UCRM of the products.

Table 3: Proximate composition of maize and cassava plant meal products

Parameters	Cassava plant meal products					
	Maize	1	2	3	SEM (±)	P value
Dry Matter (%)	88.05[b]	90.18[a]	90.17[a]	90.06[a]	0.36	0.02
Crude Protein (%)	10.38	12.62	12.25	12.51	0.56	0.55
Crude Fibre (%)	2.57	6.81	5.38	4.69	1.05	0.30
Ether Extract (%)	4.53[ab]	5.38[a]	3.12[c]	3.33[b]	0.37	0.03
Ash (%)	2.82[b]	6.69[a]	6.53[a]	6.15[a]	0.60	0.002
Nitrogen Free Extract (%)	67.75[a]	58.68[c]	62.89[b]	63.38[b]	0.07	0.001
HCN (ppm)	ND	30.00[b]	45.00[ab]	55.00[a]	4.94	0.05
ME (Kcal/g)	3156.12[a]	2907.33[c]	2941.84[b]	2963.06[ab]	49.70	0.01

[a,b,c,d] means in the same row having different superscripts differ at p <0.05; SEM: Standard Error of Means CPM 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 CPM Products 2 and 3 contained the same components but mixed at ratios 2.5:1 and 3:1, respectively.

Mineral composition of maize and cassava plant meal

The minerals composition of Cassava plant meal products and maize are presented in Table 4. There were significant differences (P<0.05) across the mineral composition of cassava plant meal (CPM) products and maize except for copper and zinc. The high Calcium (Ca) of CPM products (P < 0.05) than maize. Akinfala (6) reported lower Ca (0.28 ppm) for maize. Substitution of maize with CPM products might increase calcification of animal bone. The higher Phosphorus (P) of maize (P < 0.05) compared to CPM products may be due to high amount of phytic P contained in cereal grains, which are rarely available for animal use at digestion. Substitution of maize with CPM products might improve metabolic activities such as fatty acid transport, amino acid and protein synthesis (22). The Ca and P increased with increase in UCRM of the product.

The Magnesium (Mg) value (P < 0.05) decreased with increase in UCRM of the products. Substitution of maize with CPM products may improve osmotic regulation of the animal body and lower Ca absorption. The CPM products had highest (P < 0.05) Manganese (Mn) range (0.056 – 0.060 g/kg). Substitution of maize with CPM products might improve lipid and carbohydrate metabolism. Akinfala (6) reported lower Mn (1.06 ppm) for maize. The variations in (P < 0.05) sodium (Na) value for maize and CPM products may be due to differences in their non-starch polysaccharide fraction, which may hide them in the cellular matrix making them unavailable (22).

The CPM products showed (P < 0.05) superiority over maize for Ca, K, Cu, Mg, Mn and Cl. The lower mineral composition of maize may be due to genetic and environmental factors like irrigation frequency, soil composition and fertilizers used in planting (23).

Table 4: Mineral composition of maize and cassava plant meal products

Minerals		Cassava plant meal products				
	Maize	1	2	3	SEM (±)	P value
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 bearing different superscript in a row differ significantly (P<0.05)
Product 1 contained unpeeled cassava tuber meal mixed with leaf meal and tender stem meal at the ratio of 2:1 while the ratio of leaves to tender stems was 5:1. Products 2 and 3 contained the same component but at ratios 2.5:1 and 3:1, respectively.

Essential fatty acid composition of maize and cassava plant meal products

The essential fatty acid composition of maize and cassava plant meal products is shown in Table 5. There were significant differences (P < 0.05) across the CPM products and maize for linoleic acid, linolenic acid and Arachidonic acid. Maize had (P < 0.05) lowest linoleic acid. (1.04 %). Substitution of maize with CPM products might increase synthesis of arachidonic acid, biosynthesis of prostaglandins and cell membranes of the animal. Olomu (24) reported higher linoleic acid value (2.10 %) for maize.

The CPM product I had (P < 0.05) highest linolenic acid (0.28 %). The arachidonic acid value ranged from 1.52 % to 6.09 %. The variation obtained in all the essential fatty acids (P < 0.05) of maize and CPM products may be due to differences in their crude fiber and ether extract (25).

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

		Cassava Plant Meal				
Fatty Acid (%)	Maize	1	2	3	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]	4.87[b]	4.87[b]	0.63	0.001

Means bearing different superscript in a row differ significantly (P<0.05)
Cassava Plant Meal Product 1 contained unpeeled cassava tuber meal mixed with leaf meal and tender stem meal at the ratio of 2:1 while the ratio of leaves to tender stems was 5:1. Products 2 and 3 contained the same component but at ratios 2.5:1 and 3:1, respectively.

Amino acid composition of maize and cassava plant meal products

The amino acid (AA) composition of Cassava plant meal products and maize is shown in Table 6.

There were significant differences (P < 0.05) across the AA compositions of the cassava plant meal (CPM) products and maize for valine, tryptophan, proline and Isoleucine while no significant differences (P > 0.05)

existed for other amino acids analysed.

The valine of maize was 3.32 % higher than CPM products. Substitution of maize with CPM products might affect muscle metabolism, tissue repair and maintenance of nitrogen balance in the animal body. Olomu (24) reported ($P < 0.05$) higher value for maize (0.45 %). Maize and CPM product I had the highest ($P < 0.05$) isoleucine (4.09 %). Substitution of maize with CPM products might affect haemoglobin formation, regulation of blood sugar and energy levels. The valine, leucine and isoleucine value decreased with increase in UCRM of the products.

Maize had the ($P < 0.05$) highest tryptophan (2.16 %). Maize tryptophan value was 3.24 % higher than CPM products. Substitution of maize with CPM products may improve feed intake, protein synthesis and immune system of the animal (25). CPM Products III and I had similar ($P > 0.05$) methionine value (0.29 %). Maize proline ($P < 0.05$) was 11.97 % greater than that of CPM products. Substitution of maize with CPM products may affect the osmotic regulation and antioxidative potential of proline in the cell membrane. The proline value increased with increase UCRM of the products. The arginine, cysteine and phenylalanine increased ($P > 0.05$) with increase in UCRM of the products. The differences in the amino acids may be due to the increased proportions of these amino acids in the unpeeled cassava root or leaf meal or tender stem meal (26). Therefore, incorporation of this cassava part into the CPM mix could have resulted in improvement of these amino acid contents.

Table 6: Amino acid composition of maize and cassava plant meal products

		Cassava Plant Meal				
Amino Acids (%)	**Maize**	**1**	**2**	**3**	**SEM (±)**	**P value**
Lysine	0.63 0.35	0.61	0.47	0.55	0.03	0.35
Methionine	0.87	0.29	0.23	0.29	0.03	0.58
Arginine	1.29	0.79	0.89	0.92	0.03	0.32
Alanine	2.16^{a}	1.31	1.28	1.42	0.03	0.32
Tryptophan	1.93	2.09^{ab}	1.92^{c}	2.12^{a}	0.37	0.02
Cysteine	3.20^{a}	1.81	1.82	2.06	0.05	0.25
Valine	1.66	3.10^{a}	2.96^{ab}	2.72^{b}	0.08	0.04
Serine	2.53	1.51	1.61	1.55	0.03	0.15
Phenylalanine	1.42^{a}	2.42	2.42	2.49	0.03	0.55
Proline	4.09^{a}	1.25^{c}	1.30^{bc}	1.39^{b}	0.03	0.03
Isoleucine	4.88	4.09^{a}	3.80^{b}	3.71^{b}	0.07	0.01
Leucine		5.22	5.05	5.01	0.06	0.23

Means bearing different superscript in a row differ significantly (P<0.05)
Product 1 contained unpeeled cassava tuber meal mixed with leaf meal and tender stem meal at the ratio of 2:1 while the ratio of leaves to tender stems was 5:1. Products 2 and 3 contained the same component but at ratios 2.5:1 and 3:1, respectively.

Vitamins composition of maize and cassava plant meal products

The vitamin composition of maize and cassava plant meal products is shown in Table 7. There were significant differences ($P < 0.05$) across the CPM products and maize for all the vitamins determined. The highest ($P < 0.05$) vitamin A of maize (911.67 µg/g) might affect its role for bright sight and yolk colouration. The higher vitamin D ($P < 0.05$) of CPM

product might increase egg production and calcium absorption into the body of the animals. The differences in vitamin D and A may be due to variation in mixing ratio of the CPM products and maize cultivar.

The higher thiamine ($P < 0.05$) of CPM products may improve carbohydrate metabolism through thiamine pyrophosphate formation (TPP). The ($P < 0.05$) higher Niacin of CPM products may improve growth rate, cell metabolism and mechanism of hydrogen transfer in the living cells of animals. Likewise, the significant ($P < 0.05$) higher riboflavin of CPM products may improve hatchability of eggs and formation of flavoprotein. The vitamin A, D, thiamine, riboflavin and Niacin ($P < 0.05$) value of the CPM products decreased with increase in UCRM of the products. Lower similar values were reported by (27 and 28) when niacin, thiamine and riboflavin contents of cassava root meal and UCRM were evaluated. The higher ($P < 0.05$) range obtained from this study for the vitamins may be due to proportional addition of cassava leaf meal and tender stem meal (29)

Maize had the highest ($P < 0.05$) vitamin C (3.06 g/ml). Substitution of maize with CPM products in the diet of animals may lower oxidation – reduction activities of the animal body, transportation of Iron ions and maintenance of collagen metabolism (22). The vitamin E of CPM products increased ($P < 0.05$) with decrease in UCRM of the products. The high vitamin E ($P < 0.05$) range obtained from this study may be due to the proportional addition of cassava leaf meal and tender stem meal. Substitution of maize with CPM products may lower enzymatic digestion, protection of cells against oxidative damage caused by free radicals due to the lower value of the vitamin (29).

Table 7: Vitamins composition of maize and cassava plant meal products

		Cassava Plant Meal				
Vitamins	**Maize**	**1**	**2**	**3**	**SEM (±)**	**P value**
A (µg/g)	911.67^{a}	577.50^{b}	355.83^{c}	324.17^{c}	50.24	< 0.001
D (µg/g)	443.33^{c}	650. 00^{a}	610.00^{b}	600.00^{b}	23.88	< 0.001
E (µg/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/100 g)	0.157^{c}	0.270^{a}	0.243^{ab}	0.213^{b}	0.13	0.002
Niacin (mg/100 g)	1.467^{b}	1.833^{a}	1.700^{a}	1.667^{ab}	0.05	0.024
Riboflavin (mg/100 g)	0.077^{c}	0.130^{a}	0.103^{b}	0.093^{bc}	0.01	0.024

Means bearing different superscript in a row differ significantly (P<0.05)

Product 1 contained unpeeled cassava tuber meal mixed with leaves meal and tender stem meal at the ratio of 2:1 while the ratio of leaves to tender stems was 5:1. Products 2 and 3 contained the same component but at ratios 2.5:1 and 3:1, respectively.

Conclusion and Application

It can be concluded that:

1. Cassava plant meal products had comparable nutrient profile as maize with CPM product 1 comparatively better in all evaluated nutrient profile.
2. Cassava tender stem meal harvested at 5 cm from top of the plant should be included in the products.

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