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Assessment of the Proximate, Minerals, Vitamins, and Antinutrient Content of *Fufu* Flour made from Cassava and Cabbage

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Abstract

Cassava was traditionally processed into *Fufu* mash, dried, and processed into *Fufu* flour. Cabbage was also processed into flour. An experimental design having 7 blends were developed, sample A having 100% cassava *fufu* was used as control, sample B (5% cabbage flour / 95% cassava flour), sample C (10% cabbage flour/ 90% cassava flour), Sample D (15% cabbage flour/ 85% cassava flour), sample E (20% cabbage flour / 80% cassava flour), sample F (25% cabbage flour / 75% cassava flour), sample G (30% cabbage flour / 70% cassava flour), sample H (50% cabbage flour / 50% cassava flour). Proximate analysis was carried out both on the control and on various blends. Minerals and vitamin assays were evaluated. Statistical analysis was carried out using the 'R' statistical package. Results obtained show that the proximate compositions were significantly higher ($p<0.05$) in *fufu* with higher cabbage flour than the control with the exception of carbohydrate content and energy value, which was higher in the control (100% cassava *fufu*). Results of vitamin composition show that B-carotene, Vitamin A, B1, B2, B3, C, E, and K based on the blends increased from 1.91 ug/g, 6.33 IU, 0.06 mg/100g, 0.04 mg/100g, 0.77 mg/100g, 7.37 mg/100g, 0.40 mg/100g, 1.63 mg/100g to 7.70 ug/g, 25.65 IU, 0.08 mg/100g, 0.06 mg/100g, 0.94 mg/100g, 11.69 mg/100g, 0.53 mg/100g, 20.33 mg/100g. The phosphorus, calcium, magnesium, potassium, and sodium increased from 14.25 mg/100g, 49.54 mg/100g, 30.49 mg/100g, 71.48 mg/100g, and 12.70 mg/100g at 5% cabbage inclusion, to 37.90 mg/100g, 201.26 mg/100g, 54.01 mg/100g, 258.18 mg/100g and 41.78 mg/100g at 50% inclusion. These values were significantly higher ($p < 0.05$) than those obtained for the control (sample A) at 11.00 mg/100g, 32.16 mg/100g, 22.70 mg/100g, 18.63 mg/100g, and 12.96 mg/100g, respectively. Manganese was not detected in the control and at 5%, 10%, and 15% inclusion but was detected at 20%, 25%, 30%, and 50%. Iron was highest at 10% cabbage inclusion and lowest at 50% inclusion. 14.30 mg/100g of iron was obtained from the control (100% cassava) which was not significantly different from the value (14.06 mg/100g) obtained from sample D. Results from the anti-nutrient evaluation shows that cyanide, tannin, phytate, and oxalate increased with increase in cabbage inclusion. The values obtained are within safe limits making all the *fufu* samples safe for consumption.

Keywords: Cassava Fufu flour, Cabbage flour, Minerals, Vitamins, Anti-nutrients

Introduction

Cassava (*Manihot esculenta Crantz)* is a staple crop in Nigeria and in other West African countries (Vieira *et al*., 2011). Cassava is considered one of the most energy-dense food as a result of its high carbohydrate (>70%) content (Falade and Akingbala, 2010). Its products (*fufu, gari*, *lafun etc.*) are found in the meals of Nigerians daily (Bolade, 2016). *Fufu*, a fermented cassava product is widely accepted and consumed mostly in the southern parts of Nigeria and Central Africa for its smooth texture, characteristic aroma and white color (Bamidele *et al*., 2015). Several investigations done on the nutritional value of cassava products have all shown that cassava products have very little protein, fiber, and minerals hence the need to improve the nutritional quality of cassava *fufu* with other food products (Eleazu and Eleazu, 2012; Sanni *et al*., 2010; Famurewa et al., 2013; Bamidele et al., 2015).

Cabbage (*Brassica oleracea*) is a vegetable having a globose head with its leaf overlapping each other. Studies have shown that cabbage has good nutritional components like carbohydrates, Dietary fiber, vitamins (A, C, B, E, and K), and minerals (Potassium, Sodium, Manganese, Magnesium, Calcium, Zinc and Iron). Cabbage has in time past been consumed for its abundant nutritional value which includes dietary fibre, antioxidants, low calorie and polyphenols (Podesek, 2007). In recent times, studies have shown that cabbage and its by-products are effective in protecting the body against cancer, reducing free radicals from the human body. Dietary fiber is an important food constituent needed in the body for important chemical processes, this need has led to the development of dietary fibre products (Azizul *et al*., 2016). Post-harvest loses of vegetables have been a problem to deal with over the years, there is a need to transform these vegetables into storable products like cabbage flour. Although few research works have been conducted with cabbage flour, there is an information gap on the inclusion of cabbage flour into cassava *fufu* flour as composite *fufu* flour hence this study.

Materials and Methods

The raw materials used for this present study were healthy cassava tubers (TME 419) cultivars obtained from National Root Crops Research Institute's farm, Umudike. Fresh heads of cabbage were gotten from Orie-Ugba local market, Umuahia, all in Abia State, Nigeria.

Preparation of fufu flour

The cassava tubers were peeled, washed, and soaked in water, allowing retting by submerged fermentation process (Mokemiabeka *et al*., 2011) for 72 hours. Grated and fermented mash for 24 hours, dewatered and dehydrated at 60^0C, milled into powder, sieved, and packaged for analysis.

Preparation of cabbage flour

The heads of cabbage were washed, cut into slices, dried at 60^0C, milled into powder, sieved, and packaged for further analysis.

Formulation of cassava-cabbage blends

A two-component simplex lattice mixture experimental design was adopted for the work.

CASS + CABB = 100%

Sample A = 100% cassava flour

Sample B = 95% cassava flour + 5% cabbage flour

Sample C = 90% cassava flour + 10% cabbage flour

Sample D = 85% cassava flour + 15% cabbage flour

Sample E = 80% cassava flour + 20% cabbage flour

Sample F = 75% cassava flour + 25% cabbage flour

Sample G = 70% cassava flour + 30% cabbage flour

Sample H = 50% cassava flour + 50% cabbage flour

Proximate composition

Determination of Moisture (%)

The moisture percentage of Cassava/Cabbage *fufu* composite flour was determined according to the method described by (AOAC, 2002). Flat-bottomed dishes were washed, oven-dried and allowed to cool for 15mins in the desiccator. They were weighed and the weight of the empty cans was recorded. Exactly 5 g of each blended flour sample was put in each aluminum can and kept in the oven at 105^0C to dry until a constant weight was obtained. The cans were removed and allowed to cool in the desiccator for 15 minutes and the final weight taken. Moisture content of flours was determined in duplicate.

% Moisture was calculated using this formula:

$$\% \text{ moisture } = \frac{\text{Wt of sample } - \text{ Wt of Dried sample}}{\text{Wt of sample}} \text{x } 100 \ldots 1$$

Determination of Dietary fibre

Cassava and cabbage has a negligible fat content so crude fibre was obtained without the determination of the crude fat. 2.0g of each of the flour samples was weighed into a 7 sulphuric 750 ml Erlenmeyer flask and 0.5g of asbestos was added and 200 ml of 1.25% sulphuric acid was added to the sample with the asbestos, the flask was set on a hot plate and connected to a condenser. The contents boiled for 30 minutes, removed, and filtered using a clean linen cloth and a funnel. Boiling water was used to wash the sample during filtration in order to totally remove the acid present. The distillate was discarded and the asbestos and sample on the linen cloth were put back into the Erlenmeyer flask. 200 ml of 1.25% Sodium Hydroxide was added back into the flask and connected to the condenser, allowed to boil for 30 minutes; it was removed and filtered using the clean linen cloth. Boiled water was used to wash the sample again until the base was totally washed off. The residue was put into a porcelain crucible and put in a furnace for 30 minutes. The sample was removed, allowed to cool in desiccators, weighed and recorded (Etudaiye *et al*., 2009).

$$\% \text{ Fiber } = \frac{(y-x)-(z-x)}{(w)} \times \ 100 \ldots . 2$$

Where w = Weight of sample, x = Weight of crucible, y = Initial weight of crucible containing wet sample before ignition and z = Final weight of crucible containing ash after ignition.

Determination of Ash (%)

The percentage of Ash in the flour samples was determined using the gravimetric techniques as documented in AOAC, (2000). 10 grams of each flour blend was weighed out and put in a crucible, put in a Muffle furnace at 550^0C for 6-7 hours. When the ashing was complete, the ash was put in a desiccator to cool. After cooling, they were weighed and the weight recorded. Ash was calculated as follows;

$$\% \text{ Ash } = \frac{\text{wt of Ashed sample}}{\text{weight of sample}} \times \ 100 \ldots . 3$$

Determination of Protein (%)

Protein contents of the flour blends were determined using kejldhal digestion method as described by AOAC, (2000).

Mineral analysis

The mineral analysis was carried out using the method described by AOAC, (2005). The blends of flour samples obtained from cassava and cabbage blend was ashed using a muffle furnace at the temperature of 550^0C. 10ml of 20% HCl was added to the ash in a beaker, boiled, cooled and filtered into a standard flask of 100 ml capacity. De-ionized water was added to the filtrate making the solution up to mark. Using KCl and NaCl as standards (AOAC, 2005), the Minerals Potassium and Sodium were determined using Flame Photometer. Iron, Calcium and Magnesium were determined with the use of an Atomic Absorption Spectrophotometer. The values obtained were expressed in mg /100g. Phosphorus was determined using Vanado-molybdate method.

Vitamin Assay

Determination of Vitamin C

Vitamin C was determined by using the method as described in AOAC, (2005). 1 gram of each flour sample was macerated with 20 ml of 0.4% oxalic acid for 10 minutes and centrifuged for 5 minutes. 1 ml of the supernatant was transferred into test tubes in duplicates. 9 ml of standard 2, 6-dichlone indophenol was added and thoroughly mixed. The absorbance of the solution was read at 520 nm (AOAC, 2000).

Vitamin C was calculated thus;

$$\frac{\text{Abs x Df x Vol of Sample in cuvette}}{} \quad \ldots 4$$

Where, Abs=Absorbance, Df =Dilution Factor, E=extinction coefficient

Determination of vitamin E

Vitamin E was determined using the method in AOAC, (2005). 1g of each composite flour was put into a measuring tube; 20ml petroleum ether was added, stirred and allowed to stand for 1 hour with intermittent shaking. It was centrifuged for 5 min.3ml of the supernatant was transferred into duplicate test tubes, evaporated and the residue was further dissolved in 2 ml ethanol. 1 ml of 0.2% ferric chloride in ethanol and 1ml of 0.5% α- dipyridyl in ethanol was added to the resulting solution and made up to 5ml with ethanol. The mixture was shaken and absorbance read at 520nm wavelength against a blank. The vitamin concentration was calculated using this formula:

$$\text{Conc of Vitamin E} = \frac{\text{Abs} \times \text{Df} \times \text{Vol of Cuvette}}{} \quad \ldots. 5$$

Where, Abs=Absorbance, Df=Dilution factor, E =Extinction coefficient

Beta Carotene extraction and quantification

Beta carotene was determined using the method described by Delia, *et al*. (2004). Exactly 5 grams of each flour sample and 3 grams of celite grounded, rehydrated with 50 ml acetone and homogenized properly using a mechanical blender for 1 to 2 minutes, filtered with a sintered glass funnel. After filtration the residue is returned to the blender and re-extracted with 25 ml of fresh solvent. Extraction and filtration are repeated until the residue is bleached (becomes colourless). The extract was poured into a 250 ml separating funnel containing 30 ml petroleum ether and washed with water. A few drops of saturated Sodium chloride solution were added to the funnel to facilitate phase separation. The aqueous layer was removed and the upper layer was transferred to a 50 ml volumetric flask and made up to mark using petroleum ether.

Calculation:

$$\text{Beta Carotene} (\mu g/g) = \frac{A \times V \times 10^4}{\text{W x Absorption Coefficient}} \quad \ldots 6$$

Where, A=absorbance of sample, Absorption coefficient =2592, V= volume of sample used (50m)

The value of beta-carotene was converted to vitamin A using the conversion unit of 3.33IU.

Vitamin A determination

Exactly 1 gram of each flour sample was put into a beaker, 200ml of petroleum ether was added and stirred for 10 min, allowed to stand for 1 hour, and centrifuged for 5min. 3 ml of the supernatant was transferred into duplicate test tubes, evaporated and further dissolved in 0.2ml of acetic anhydride / chloroform (1:1) and 2 ml of 50% trichloroacetic acid (TCA) in chloroform. The absorbance was read at 620nm wavelength.

Vitamin K determination

Vitamin K was determined using High Performance Liquid Chromatography (Booth *et al*., 1994)

Determination of anti-nutritional composition

Hydrogen cyanide Determination

Hydrogen cyanide was determined using spectrophotometric method of AOAC, (2012).

Phytate Determination

Phytic acid was determined using a method described by AOAC, (2012). Exactly 2g of each flour sample was weighed into a 250ml conical flask. 100ml of 2 % conc. HCl acid was added into the flask and allowed to soak for 3 hours. It was filtered into a clean conical flask using whatman No 1 filter paper. 50 ml of the filtrate was collected and put into a separate 250ml beaker. 10ml of 0.3% ammonium thiozyanate solution was added to each of the sample solution as indicator and titrated with standard Iron (111) Chloride solution containing 0.00195g. The end point was indicated by a brownish yellow color.

Phytic acid was calculated thus:

$$\text{Phytic acid} = \frac{T \times 0.00195 \times 1.19}{2} \times 100 \;....\; 7$$

Oxalate Acid determination

Oxalate was determined using method by AOAC, (2012). I g of each flour sample was weighed into 100ml conical flask. 95ml of 3N H_2SO_4 was added and stirred carefully using magnetic stirrer for 1 hour, filtered. 25ml of the filtrate was collected and titrated against hot 0.1N $KMnO_4$ solution to a pink coloured solution as endpoint. The concentration of oxalate in the flour samples was calculated.

Tannin determination

Tannin was determined using the rapid test method of Association of Official Analytical Chemists, (2005).

Statistical analysis

Data obtained from the experiments was statistically analyzed using R Statistical Package, version: 4.1.2

Results and Discussion

Proximate composition

Moisture Content

From the result obtained, the moisture contents of the different blends of cassava/cabbage *fufu* composite flour as presented in Table 2 were in the range of 7.55% in Sample A (Control) to 10.6% in Sample H. There was no significant difference ($p>0.05$) between Samples A (Cass 100%), B (Cass 95%, Cabb 5%) and C (Cass 90%, Cabb 10%) moisture contents. Sample D showed no significant difference with the first three Samples. However, the moisture contents of flour samples H (Cass 50%, Cabb 50%), G (Cass 70%, Cabb 30%) and F (Cass 75%, Cabb 25%) were significantly higher ($p<0.05$) than the Control and other blends. The moisture content obtained in the control (100% Cassava *fufu* flour) was in line with that reported by Ogbonnaya *et al.*, 2018. It was observed that there was higher moisture in the blends that had more cabbage, with Sample H having the highest (10.6%). However, moisture contents of the different flours (Samples A, B, C, D and E) were generally low (<10%) and agrees with FAO recommendations for flour samples (FAO/WHO, 1991). Moisture content of flour is very important. The low moisture values show a stable shelf life when packaged and stored properly. There is danger of bacteria and mould attack on flours with moisture above 14% which results to short shelf life (Ihekoronye and Ngoddy, 1985). All moisture contents of the flours were within the acceptable limit.

Fat Content

The Fat contents of the *fufu* flour blends ranged from 0.66% in Sample A to 1.25% in Sample H. It was observed from the result obtained that the addition of cabbage to the traditional prepared *fufu* flour affected the fat content of the flour blends although the value of fat in the control (Cass 100%) sample does not show any significant difference ($p>0.05$) with Sample B (Cass 95%, Cabb 5%) fat content, there was a significant difference between Sample A, E, F, H and G.

Dietary Fiber Content

The fiber contents varied from 0.32 to 12.57% in the flour samples. The addition of cabbage to cassava *fufu* flour increased the fiber reasonably. The control sample (100% Cass) recorded the least fiber content while Sample H (Cass 50%, Cabb 50%) had the highest fiber content. Dietary fiber is a measure of the amount of indigestible cellulose, pentosans, lignin in foods. I is the residual portion left of the plant material after solvent extraction followed by digestion with dilute acid and alkali. It has little food value but provides the bulk needed for peristaltic action in the intestinal tract. Dietary fiber lowers the concentration of low density lipoprotein cholesterol in the blood. Fibers play a vital role in our gastrointestinal tract by eliminating waste; they have the ability to bind water, softening the stool thereby preventing constipation (FAO, 1998).

Protein Content

The protein values obtained from the analysis ranged from 0.76 – 5.18% in the *fufu* flour samples. The protein values in the flour samples increased significantly ($p<0.05$) with increase in cabbage flour. Sample A (Cass 100%) which is the control had the least protein content (0.76%) while Sample H (Cass 50%, Cabb.50%) had the highest protein content (5.18%).

Ash Content

Ash is the mineral material in flour. The ash content varied between 0.44% in Control Sample A (100% *fufu* flour) and 3.46% in Sample H (Cass 50%, Cabb 50%). The values of ash obtained from the flour blends with cabbage were significantly higher ($p<0.05$) than the control sample. This increase could be attributed to the fact that cabbage is a good source of minerals like potassium (USDA, 2017).

Carbohydrate content

The carbohydrate content of 100% cassava *fufu* in this present study gave 91.03% and cabbage flour gave 56.91% as presented in Table 1. This value is in line with the findings of Olapade *et al*., (2014) which were reported in their work quality attributes of *fufu* flour supplemented with Bambara flour. The carbohydrate content of cassava/cabbage *fufu* composite flour ranged from 90.20% in 5% cabbage inclusion to 72.12% in 50% cabbage inclusion. The carbohydrate contents of the flour reduced significantly with an increase in the percentage of cabbage flour.

Gross Energy

There was a significant decline in the energy value of some blends which ranged from 365 Kcal in Sample D (15% cabbage flour) to 349 Kcal in Sample H (50% cabbage flour) compared to 373 Kcal in the control sample with 100% cassava *fufu.* The Energy value of Sample B (with 5% cabbage flour), and Sample C (10% cabbage flour) does not differ from that of the control.

Mineral composition

Table 3 the Mineral composition of 100% cassava flour and cabbage flour while Table 4 shows the Mineral Composition of Cassava – Cabbage blends.

Phosphorus Content

In this present study, the phosphorus content of sample A (100 % Cassava *fufu* flour) was 11.00mg/100g while the cassava/cabbage composite flour blends ranged from 14.25 – 37mg/100g from sample B to sample H. Phosphorus content increased significantly ($p<0.05$) with an increase in percentage of cabbage. The recommended dietary allowance ranges from 275 mg (infants) to adolescents (1250 mg), to adults (700 mg) (Institute of Medicine, 2011). The phosphorus contents of the flours are below the RDA for all ages.

Calcium

Calcium plays an important role in the formation of bone and in the neurological function of the body. Lack of calcium causes rickets in children and osteoporosis in adults (Oluwajuyitan and Ijarotimi, 2019). The results obtained from the flours ranged from 32.16 mg/100g in Sample A (control), Sample B (49.54 mg/100g), Sample C (59.46 mg/100g), Sample D (68.64 mg/100g), Sample E (95.21 mg/100g), Sample F (121.20 mg/100g), Sample G (136.26 mg/100g), and Sample H (201.26 mg/100g). These values obtained from the various blends were significantly different ($p<0.05$) from each other and from the control. It was observed that the calcium content increased with an increase in cabbage flour. The recommended daily intake of calcium by FAO/WHO (1991) for adults is 1000 mg, for a child is 700 mg while for infants is 260 mg. Sample H provides 20% of the recommended daily intake for adults. According to the USDA, (2016) report, the calcium content of raw cassava was 16 mg/100g which is lower than the result obtained in this study for 100 % cassava *fufu*. The higher value obtained could be as a result of varietal differences and processing methods. A work done by Olusola *et al.,* (1989) on the effects of fermentation on mineral content of cassava during *fufu* production showed that calcium content of 50 mg/100g for raw cassava increased to 55 mg/100g after fermentation.

Magnesium

Magnesium content of the control sample gave 22.70 mg/100g while that of the other flour blends varied from 30.49 to 54.01mg/100g, from Sample B to H. The magnesium content of the control sample was significantly lower ($p<0.05$) than the flour blends containing cabbage flour and there was significant increase with increase in percentage cabbage flour. Magnesium helps in the maintenance of osmotic equilibrium in the body (Bhowmik and Datta, 2012). It is said that excess of magnesium causes depression of the nervous system (Bhowmik and Datta, 2012). The recommended daily allowance of Magnesium ranges from 75 mg (for infants) to 420 mg (for adults) (Institute of Medicine, 2006). Flour samples containing cabbage can provide up to 50 % of the RDA for infants and 13 % of the RDA for Adults.

Potassium

Potassium content of the flours ranged from 18.63 mg/100g in Sample A to 258.18 mg / 100g in Sample H. The control sample had the lowest potassium content (18.63 mg/100g) which was significantly different from the potassium contents of the various flour blends. The value of potassium in 100% cassava *fufu* was higher than the value obtained by Bamidele *et al.,* (2015), this could be due to varietal differences.

Potassium is an electrolyte needed for healthy body which conducts electrical impulses all over the body, it is vital in the normal functioning of kidney and blood pressure control (Osagie, 1992). Potassium is also needed in bone and muscle maintenance and the transmission of messages through the nervous system (Deborah, 2019). The recommended dietary allowance of potassium for infants to adults ranged from 860 mg to 3400 mg per day (NASEM, 2019). Sample H can provide 30% of RDA for infants and 7.5% for adults.

Sodium

The sodium content of the studied flours varied from 12.96 mg/100g (Sample A) to 41.78 mg/100g (Sample H). Sodium content increased in the flour samples with an increase in percentage cabbage flour. Sodium is essentially involved in the transport of metabolites and in blood pressure enhancement (Bhowmik and Datta, 2012; Micheal and Enrico, 2006). Sodium is a vital mineral responsible for the control of water balance in the body, impulse regulation and muscle contraction (Chima, 2012). The human body needs a small amount of sodium for normal body function, too much of it can cause serious health issues like high blood pressure which can eventually lead to stroke and heart disease. The daily recommended value for sodium for infants (6 months) to adults ranges from 370 - 2,300 milligrams (mg) per day (NASEM. 2019).

Zinc

The zinc content of the 100% cassava *fufu* flour was 2.58 mg/100g, which was significantly higher than the zinc content in the rest of the flour blends. Sample C (1.00 mg/100g) and D (0.99 mg/100g) were not significantly different from each other, same for Sample E (1.58 mg/100g) and F (1.65 mg/100g). Sanni *et al*, (2010) reported a lower value for unfortified *fufu* (4.00 mg/kg). The required daily allowance (RDA) of zinc for infants, children, adolescents, and adult males and females ranges between 3.0 mg/100g to 11.00 mg/100g (NASEM, 2019). Flours with cabbage had lower values of zinc than the daily allowance (RDA) but sample H can provide 69% of RDA for infants. The upper level for Zinc is 40 mg per day. Zinc is a mineral necessary for immune cell development and development. It has multiple metabolic roles in the human body. A deficiency in this nutrient affects the immune system normal functioning which results in an increased risk of infection, it causes poor appetite, delayed wound healing and neurosensory disorders (Ananda, 1995).

Manganese

Manganese was not detected in Samples A to D. Manganese varied from 0.03 – 0.99 mg/100g from Sample E to Sample H. Manganese content of Sample H was significantly higher than those in the other flour blends. Results obtained from this study were lower than the recommended dietary allowance (RDA) which ranged from 2.5 – 3 mg/day (NASEM, 2019). Manganese is an essential mineral indispensable for bone formation. It is a vital co-factor in enzymes that facilitate the metabolism of proteins, carbohydrates and fats. It activates antioxidant enzymes in the body, preventing free radicals. Its deficiency in the body causes cartilage and connective tissue disorders (squeaky knees), low fertility, and abnormal metabolism of carbohydrates and fats. High concentration of manganese poses health problems like hallucinations, forgetfulness and nerve damage (Johnson, 2003).

Iron

The iron contents of the flour blends ranged from 14.30 mg/100g in Sample C, 11.68 mg/100g in Sample B, 16.57 mg/100g in C, 14.06 mg/100g in D, 13.37 mg/100g in E, 12.44 mg/100g in F, 10.77 mg/100g in F and 13.16 mg/100g in H. the highest value is seen in Sample C. The value of Iron in the control (100% cassava) was higher than that obtained by Olusola and Odunfa, (1989) on 100% cassava *fufu*. Sanni, *et al*, (2010) recorded 8.50 mg/kg for unfortified *fufu* which is lower than the value obtained in this study for 100% cassava *fufu*. These variations could be linked to varietal differences. Iron is a vital micronutrient for the formation of hemoglobin in the human body. Carbohydrates, proteins and fats undergo oxidation with the help of Iron. It also helps in the normal functioning of the central nervous system (Adeyeye and Otokiti, 1999). The iron content of the flour was higher than the daily recommended dietary allowance (1.37mg/day) for men and females (2.94mg/day) (Hall, 2009).

Vitamin composition

Table 5 shows the vitamin composition of cassava flour and cabbage flour while Table 6 contains the vitamin composition of various blends of cassava/cabbage flours.

Beta-carotene

Beta-carotene ranged from 1.91 - 7.70 µg/g. The value obtained for sample A (control) was significantly lower than for other samples. It was observed that the beta-carotene content was increased with an increase in the inclusion of cabbage powder. Omodamiro *et al*., (2012) reported 0.35 µg/g Beta-carotene content for TMS 30572 – white root. This variation in beta-carotene could be attributed to varietal differences.

Vitamin A

Vitamin A contents of the 100% Cassava *fufu* (sample A) and other samples ranged from 6.33 IU to 25.65 IU. The vitamin content of the 100 % cassava *fufu* flour was significantly lower than the flours with cabbage flour. The inclusion of cabbage flour improved the vitamin content of the *fufu* flour. Vitamin A is a fat-soluble vitamin, an important micronutrient needed in the body. It is essential for night vision, maintenance of skin and mucosal integrity. Vitamin A also stimulates the production of white blood cells and regulates cell growth and division during reproduction. Deficiency results in night blindness or permanent blindness in severe cases. Vitamin A occurs in many forms, such as retinol (alcohol), retinal (aldehyde), retinyl acetate (esters) and provitamin A carotenoid. The recommended dietary allowance is 900 mcg daily for males and 700 mcg daily for females (NASEM, 2019).

Vitamin B1 (Thiamin)

The value of Vitamin B1 obtained from the analysis of the cassava / cabbage flour blends ranged from 0.06 mg / 100g to 0.08 mg / 100g, from Sample A (control) to Sample H (50% Cass / 50% Cabb) as shown in Table 6. The value obtained for 100 % cassava *fufu* was significantly lower ($p<0.05$) than those obtained from the *fufu* with cabbage flour. The introduction of cabbage flour increased the vitamin B1 contents of the *fufu* flours. Thiamin or vitamin B1 is a water-soluble vitamin which plays a vital role in the growth and proper functioning of most cells in the body. It also helps in the breakdown of nutrients for energy. The Recommended Dietary Allowance (RDA) for men (19 and older) is 1.2 mg daily while that of women of same age range is 1.1 mg daily. Sample A provides 5 % of the daily requirement of vitamin B1 while the introduction of cabbage flour increased it to 6 to 7 %. A deficiency of vitamin B1 can lead to Beriberi (Jacobs, 2014; Thurnham, 2013).

Vitamin B2 (Riboflavin)

The values obtained from this present study ranged from 0.04 mg / 100g to 0.06 mg / 100g, from Sample A to H. The addition of cabbage flour slightly increased the vitamin in the *fufu* significantly. This Vitamin is a component of coenzymes responsible for the growth of cells, the production of energy and in the breakdown of fats and medications. The Recommended Dietary Allowance is 1.3 mg and 1.1 mg daily for men and women respectively (Fishman *et al*., 2000). Deficiency of this vitamin can lead to cardiovascular diseases and migraines.

Vitamin B3 (Niacin)

Vitamin B3 ranged from 0.77 to 0.94 mg /100g, from sample A to H. There was significant increase in the vitamin B3 content of *fufu* flour with an increase in the addition of cabbage flour. This is a water-soluble B vitamin. It works in the body as a coenzyme, and converts nutrients to energy. The Recommended Dietary Allowance is 16 mg NE for men and 14 mg NE for women (NASEM, 2019). Deficiency of this vitamin can lead to depression, memory loss and hallucinations (Morris *et al*., 2004).

Vitamin C (Ascorbic Acid)

Vitamin C ranged from 7.37 to 11.69 mg / 100g, from sample A to H. The content of Vitamin C in the 100% cassava *fufu* flour appreciated with the addition of cabbage flour. Vitamin C is a water-soluble vitamin, a powerful antioxidant that neutralizes harmful free radicals. It also supports the function of various immune cells and increases their ability to fight against infections (Traber and Stevens, 2011). The vitamin helps in the production of collagen and other hormones needed in the brain and nerves (Afoakwa *et al.,* 2010b). The Recommended Dietary Allowance for Adults 19 years and above is 90 mg daily for men and 75 mg for women. The upper limit for vitamin C is 2000 mg daily (NASEM, 2019).

Vitamin E

The Vitamin E obtained from this study varies from 0.40 mg/100g to 0.53 mg/100g. There was no significant difference (p>0.05) between the value of vitamin E obtained from Sample A (control) and the other flour samples containing cabbage flour. Vitamin E is fat-soluble vitamin, an antioxidant (Traber and Stevens, 2011) required for the proper functioning of many organs in the body. Deficiencies of this vitamin which is rare results in genetic movement disorder (Traber, and Atkinson, 2007). The recommended dietary allowance for adults is 2000 mg daily (NASEM, 2019).

Vitamin K

Vitamin K ranged from 1.63 – 20.33 mg/100g, from sample A to sample H in this study. There was significant increase of vitamin k with the inclusion of cabbage flour to the cassava *fufu* flour. This is a fat-soluble vitamin, it is vital for blood coagulation, controls binding of calcium in bones (Marriott *et al*., 2020). Deficiency of this vitamin can lead to prolonged bleeding in case of injury.

Conclusion

Cassava consumers are at high risk for inadequate Vitamin and mineral intake, so this study is an effort to ameliorate this risk.From the results obtained from this present study, the inclusion of cabbage flour to cassava *fufu* flour in the production of *fufu* dough resulted in enriched *fufu* with higher protein, fiber, mineral composition, and vitamins. The moisture contents of the various flour blends were below 14 % making them desirable and good for storage. Cassava – Cabbage flour can be used to address the micronutrient deficiencies in developing countries of the world. A further study on antioxidant properties, glycemic index and texture profile analysis of this work is highly recommended.

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Table 1: Proximate Composition of Cassava *fufu* flour and Cabbage flour (per 100 g D.W.)

Parameters	Cassava *fufu* flour	Cabbage flour
Moisture (%)	7.55^{b}	10.05^{a}
Fat (%)	0.66^{b}	1.72^{a}
Fibre (%)	0.32^{b}	24.82^{a}
Protein (%)	0.76^{b}	9.65^{a}
Ash (%)	0.44^{b}	6.50^{a}
Carbohydrate (%)	91.03^{a}	56.91^{b}
Energy (Kcal)	373.1^{a}	281.72^{b}

In a row, numbers of different superscripts are significantly different at p<0.05

Table 2: Proximate Composition of *Fufu* flour made from Cassava and Cabbage

Sample	MC (%)	Fat (%)	Crude Fiber (%)	Protein (%)	Ash (%)	CHO (%)	Energy (Kcal)
A	7.55^{e}	0.66^{e}	0.32^{h}	0.76^{h}	0.44^{g}	91.03^{a}	373^{a}
B	7.70^{e}	0.88^{d}	0.63^{g}	1.19^{g}	0.59^{f}	90.20^{b}	373^{a}
C	7.85^{e}	0.91^{cd}	0.89^{f}	1.64^{f}	0.89^{e}	89.46^{c}	372^{a}
D	8.90^{de}	0.93^{d}	1.89^{e}	2.09^{e}	1.11^{d}	87.17^{d}	365^{b}
E	9.80^{cd}	0.97^{c}	3.95^{d}	2.30^{d}	1.21^{c}	84.07^{e}	354^{c}
F	10.10^{bc}	1.00^{bc}	6.29^{c}	2.43^{c}	1.27^{bc}	81.34^{f}	344^{d}
G	10.40^{b}	1.10^{b}	8.61^{b}	2.60^{b}	1.34^{b}	78.55^{g}	334^{d}
H	10.60^{a}	1.25^{a}	12.57^{a}	5.18^{a}	3.46^{a}	72.12^{h}	320^{e}

Means within the same column followed by the same letter are not significantly (p>0.05) different
Sample A = 100 % cassava fufu flour, Sample B = 95 % cassava fufu flour / 5 % cabbage flour, Sample C = 90 % cassava fufu flour / 10 % cabbage flour, Sample D = 85 % cassava fufu flour / 15 % cabbage flour, Sample E = 80 %cassava fufu flour / 20 % cabbage flour, Sample F = 75 % cassava fufu flour / 25 % cabbage flour, Sample G = 7 0 % cassava fufu flour / 30 % cabbage flour

Table 3: Mineral composition of cassava *fufu* flour and cabbage flour.

Parameters	Cassava *fufu* flour	Cabbage flour
Phosphorus (mg/100g)	11.00^{b}	64.80^{a}
Calcium (mg/100g)	32.16^{b}	370.36^{a}
Magnesium (mg/100g)	22.70^{b}	85.32^{a}
Sodium (mg/100g)	12.96^{b}	70.6^{a}
Zinc (mg/100g)	2.58^{b}	1.56^{a}
Manganese (mg/100g)	ND	0.79^{b}
Iron (mg/100g)	14.30^{a}	12.02^{b}

In a row, numbers followed by different letters differ significantly at p<0.05

Table 4: Mineral Composition of *Fufu* flour made from Cassava and Cabbage.

Samples	P (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	K (mg/100g)	Na (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Fe (mg/100g)
A	11.00^{g}	32.16^{h}	22.70^{g}	18.63^{h}	12.96^{f}	2.58^{a}	ND	14.30^{b}
B	14.25^{f}	49.54^{g}	30.49^{f}	71.48^{g}	12.70^{f}	1.91^{c}	ND	11.68^{e}
C	18.95^{e}	59.46^{f}	35.42^{e}	108.41^{f}	14.52^{e}	1.00^{e}	ND	16.57^{a}
D	17.45^{e}	68.64^{e}	40.59^{d}	141.96^{e}	17.61^{d}	0.99^{e}	ND	14.06^{b}
E	23.50^{d}	95.21^{d}	44.27^{c}	163.91^{d}	22.30^{c}	1.58^{d}	0.03^{d}	13.37^{c}
F	26.00^{c}	121.20^{c}	46.67^{b}	181.35^{c}	21.65^{bc}	1.65^{d}	0.27^{c}	12.44^{d}
G	28.75^{b}	136.84^{b}	46.96^{b}	191.58^{b}	23.35^{b}	ND	0.35^{b}	10.77^{f}
H	37.90^{a}	201.26^{a}	54.01^{a}	258.18^{a}	41.78^{a}	2.07^{b}	0.99^{a}	13.16^{c}

Means within the same column followed by the same letter are not significantly (p>0.05) different
Sample A = 100 % cassava fufu flour, Sample B = 95 % cassava fufu flour / 5% cabbage flour, Sample C = 90 % cassava fufu flour / 10 % cabbage flour, Sample D = 85 % cassava fufu flour / 15 % cabbage flour, Sample E = 80 %cassava fufu flou r / 20 % cabbage flour, Sample F = 75 % cassava fufu flour / 25 % cabbage flour, Sample G = 70 % cassava fufu flour / 30 % cabbage flour.

Table 5: Vitamin Composition of Cassava *fufu* flour and Cabbage flour

Parameters	Cassava *fufu* flour	Cabbage flour
Vitamin A (IU)	6.33[b]	44.97[a]
Vitamin B1 (mg/100g)	0.06[b]	0.10[a]
Vitamin B2 (mg/100g)	0.04[b]	0.10[a]
Vitamin B3 (mg/100g)	0.77[b]	1.11a
Vitamin C (mg/100g)	7.37[b]	16.01[a]
Vitamin E (mg/100g)	0.04[b]	0.66[a]
Vitamin K (mg/100g)	1.63[b]	39.03[a]

In a row, numbers followed by different letters differ significantly at p<0.05

Table 6: Vitamin Composition of *Fufu* flour made from Cassava and Cabbage.

Samples	B-Carotene (Ug/g)	Vitamin A (IU)	Vitamin B1 (mg/100g)	Vitamin B2 (mg/100g)	Vitamin B3 (mg/100g)	Vitamin C (mg/100g)	Vitamin E (mg/100g)	Vitamin K (mg/100g)
A	1.91[h]	6.33 [h]	0.06[c]	0.04[d]	0.77 [e]	7.37[c]	0.40[a]	1.63[h]
B	2.18 [g]	7.26 [g]	0.06[c]	0.04[d]	0.65 [f]	8.08[bc]	0.45[a]	3.49[g]
C	2.53 [f]	8.43 [f]	0.07[b]	0.04[d]	0.80[de]	8.39[bc]	0.42[a]	5.22[f]
D	2.75 [e]	9.16 [e]	0.07[b]	0.05[c]	0.83[c]	7.91[bc]	0.44[a]	7.09[e]
E	3.55 [d]	11.81 [d]	0.07[b]	0.05[c]	0.85[bc]	9.28[bc]	0.47[a]	8.94[d]
F	4.04 [c]	13.47 [c]	0.07[b]	0.05[c]	0.88[b]	9.62[b]	0.49[a]	10.60[c]
G	4.65[b]	15.50 [b]	0.07[b]	0.06[b]	0.90[ab]	9.88[ab]	0.50[a]	12.67[b]
H	7.70[a]	25.65[a]	0.08[a]	0.07[a]	0.94[a]	11.69[b]	0.53[a]	20.33[a]

Means within the same column followed by the same letter are not significantly (p>0.05) different
Sample A = 100 % cassava fufu flour, Sample B = 95 % cassava fufu flour / 5% cabbage flour, Sample C = 90 % cassava fufu flour / 10 % cabbage flour, Sample D = 85 % cassava fufu fl our / 15 % cabbage flour, Sample E = 80 %cassava fufu flour / 20 % cabbage flour, Sample F = 75 % cassava fufu flour / 25 % cabbage flour, Sample G = 70 % cassava fufu flour / 30 % cabbage flour

Table 7: Anti-nutrient Composition of Cassava *fufu* Flour and Cabbage flour

Parameters	Cassava *fufu* flour	Cabbage flour
Cyanide (mgHCN/g)	3.26[b]	15.20[a]
Tannin (mg/100g)	0.43[b]	6.50[a]
Phytates (mg/100g)	0.78[b]	11.6[a]
Oxalates (mg/100g)	0.43[b]	7.32[a]

In a row, numbers followed by different letters differ significantly at p<0.05

Table 8: Anti Nutrients Composition of *Fufu* flour Cassava and Cabbage

Samples	Cyanide (mgHCN/g)	Tannin (mg/100g)	Phytate (mg/100g)	Oxalate (mg/100g)
A (100% Cassava)	3.26[h]	0.43[d]	0.78[f]	0.43 [f]
B (95% Cass / 5% Cabb)	3.62[g]	0.48[c]	1.72[e]	0.59[e]
C (90% Cass / 10% Cabb)	4.24[f]	0.50[bc]	2.68[d]	0.64[de]
D (85% Cass / 15% Cabb)	6.09[e]	0.52[b]	3.64[c]	1.69[d]
E (80% Cass / 20% Cabb)	7.45[d]	0.55[a]	4.63[d]	1.73[c]
F (75% Cass / 25% Cabb)	8.09[c]	0.53[ab]	4.71[c]	1.75[bc]
G (70% Cass / 30% Cabb)	8.27[b]	0.55[a]	5.58[b]	1.81[b]
H (50% Cass / 50% Cabb)	11.60[a]	0.57[a]	5.92[a]	2.95[a]

Means within the same column followed by the same letter are not significantly (p>0.05) different
Cass = cassava, cabb = cabbage