RESEARCH ARTICLE

NUTRITIONAL, ANTI-NUTRITIONAL, AND SENSORY PROPERTIES OF COWPEA HULL-ENRICHED *GARI*

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Highlights

- Inclusion of cowpea hull (before and after fermentation) significantly increased the nutritional profile
- The fermented cowpea hull reduced the anti-nutritional properties than their unfermented counterpart
- Inclusion level above 5 % was rated as 'low' by the sensory panelist due to change in appearance

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NUTRITIONAL, ANTI-NUTRITIONAL, AND SENSORY PROPERTIES OF COWPEA HULL-ENRICHED *GARI*

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Abstract: In continuous search for solutions to malnutrition, mainly prevalent among the people of developing countries, various views have been expressed regarding the necessity to improve the nutritional quality of indigenous foods such as *gari* through better processing and enrichment with cheap and readily available plant materials such as cowpea hull. *Gari* was produced using the traditional method and enriched with freshly produced cowpea hull in dry form to improve the nutritional composition. The objective of this study was to determine the effect of stages of inclusion of cowpea hull on some quality attributes of *gari*. Factorial design of 2 stages of inclusion (before and after fermentation) with 4 levels (0 %, 3 %, 5 % and 7 %) of cowpea hull treatments and standard methods were used to analyze the enriched *gari* (EG). The results of the proximate analysis of *gari* revealed that as inclusion level increases crude fibre, ash and crude protein contents increased in the fermented EG. Enrichment caused a significant ($p<0.05$) increase in the minerals and the amino acid profile compared to the control while fermentation caused a significant increase in vitamins content of EG. The titratable acidity of the EG may be linked to the increase in amino acid content of the samples, and pH ranged from 3.87 to 3.99. Fermentation of the cowpea hulls with cassava mash significantly enhanced the sensory characteristics and make them acceptable than their unfermented counterpart. Based on the results, it is recommended to enrich *gari* by incorporating 7% cowpea hull that have undergone fermentation with cassava mash.

***Keywords**:* Nutritional; Anti-nutritional; *Gari*; Cowpea hull; Sensory

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a staple food that matches the population growth in Nigeria because it is readily available in Nigeria and has been ranked as the largest producer (FAO, 2021). It has been described as the most important crop in Nigeria owing to its food security status, ability to store its matured edible roots in the ground for about three years, in addition to providing dietary energy for close to a billion people and livelihood for millions of farmers, processors and traders worldwide (FAO, 2018; Ikuemonisan et al., 2019). Its perishability nature, low protein content and potential toxicity limit its use. It is used across cultures, grown virtually in all the states in Nigeria, and widely eaten by all, though processed differently. The majority of the root produced is locally consumed as traditional meals. It is the most important crop by production, and the second most consumed crop after maize which is capable of growing on marginal soils because of its drought-tolerant nature (Wossen, 2017; Otekurin, 2019). It fits well into the farming system of small holder farmers in Nigeria because it is available throughout the year, thus providing food security for households. Cassava can be transformed into various products such as *gari, lafun, fufu*, tapioca and many other West African traditional dishes (Afoakwa et al., 2010; Karim et al., 2017). However, cassava and its products are low in protein (3.6 to 4.4 % dry weight basis) and deficient in essential amino acids, phytochemicals, vitamins, minerals and therefore have low protein quality, with a protein content of 3.6 and 4.4% dry weight (Oboh & Akindahunsi, 2003). This has limited the nutritional value of products from cassava.

Gari is a creamy, white granular flour with a slightly fermented flavor and a slightly sour taste made from fermented, gelatinized fresh cassava tuber (IITA, 2005). It is the most popular cassava product consumed in West Africa and the most important food product in the diet of millions of Nigerians (Afoakwa et al., 2010). It has a very low level of protein probably because of this; kwashiorkor is believed to be prevalent in the area where cassava is the staple items of diet. With the prevalence of malnutrition in the society, there is need to enrich our diets with protein using a cheap source of protein that is found in legume family. Although *gari* is never eaten alone as a full meal but rather taken with vegetable stew to satisfy other nutrient requirements and this also depends on the animal protein content of the stew. However, because of the high cost of animal proteins, majority of the population cannot afford such fortification for *gari*, hence the need to search for cheaper and good quality protein sources that are readily available for the enrichment of *gari* such as soybean, Bambara groundnut, okra, Amaranth grain, moringa etc. have been reported.

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Food enrichment is an important method of putting an end to malnutrition and its forms across various strata, which ensures the right diet intake without altering eating habits (Adelodun & Sanni, 2009). Malnutrition is a major problem facing developing countries like Nigeria, and micronutrient deficiency is an important feature of this twisted problem. A recent report indicated that there was a high level of under nutrition in Nigeria, and that the diet was too low in micronutrients and too high in carbohydrates (Onimawo et al., 2006).

This study therefore aimed at enriching *gari* with cowpea hull. Cowpea seed hull is a crop residue (by-product), which is available in Nigeria in large quantities. The percentage of cowpea hull to a whole seed is 3.65 % to 4.96 % cowpea hull for brown and black-eyed cowpea, respectively (Reichert et al., 1979). The high percentage of bye-product gotten during the production of bean pudding, bean soup (*gbegiri*), bean cake (*moi-moi*), fried bean cake (*akara*), cowpea flour and many more are thrown away and it is very high in fibre, proteins, vitamins and minerals (Adebiyi et al., 2010).

Adebiyi et al. (2010) evaluates the nutritional qualities of physically treated cowpea hull in poultry feed and the results revealed that the different processing methods could increase the crude protein contents with a reduction in crude fibre of the seed hull. These changes may be due to fermentation that occurred during the soaking of the cowpea hull, thus indicating that fermentation can boost the nutritional potentials of the hull. Therefore, in a bid to harness nutritional status of millions of people in Africa including Nigeria to resolve the shortage of nutrient intake and environmental pollution, this study was designed to utilize, assess the nutritional qualities in this crop residue and to ascertain if simple physical treatments will boost these potentials.

MATERIALS AND METHODS

Freshly harvested cassava root variety (TME 419) was harvested from Root and Tuber Expansion Programme (RTEP) farm in Ajase-Ipo, Kwara State. The cassava roots were at the point of harvest maturity. The roots were packed in jute bags and immediately transported to the *gari* production factory in the Teaching and Research Farm of the Faculty of Agriculture, University of Ilorin, Nigeria for processing into *gari*.

Production of Cowpea Hull

Dried cowpea seeds (Kananado Yar Variety) which were free from insect infestation or chemical residues were used in this study to obtain cowpea seed hull. The cowpea seed hull was extracted using a manual method. The seeds were cleaned to remove stone, debris, unwanted particles, sands etc. and then soaked in clean water for 7 min. for easy separation of the hull from the seed. After de-hulling, the hulls were then cleaned again to remove residual dirt or husk then roasted (>60 ^{o}C for 10mins.) in a dry stainless steel pot and finally cooled at room temperature for 1hr to make it ready for use and prevent mould formation during storage.

Experimental Design

A factorial design of two stages of inclusion and four levels of cowpea hull totaling eight treatments including of a control with no inclusion of cowpea before and after fermentation (100% cassava) was used in the study (Table 1).

Table 1: Relative percentages of Gari (G) and Cowpea hull (C) used in the production of Cowpea Hull-Enriched Gari. Cowpea hull is added before or after fermentation (F and NF, respectively). **Key to treatments;** G_{100}: 100% *gari*; $G_{97}CF_3$: 97 % *gari*: 3 % cowpea hull added before fermentation; $G_{95}CF_5$: 95 % *gari*: 5 % cowpea hull added before fermentation; $G_{93}CF_7$: 93 % *gari*: 7 % cowpea hull added before fermentation; $G_{97}CNF_3$: 97 % *gari*: 3 % cowpea hull added after fermentation; $G_{95}CNF_5$: 95 % *gari*: 5 % cowpea hull added after fermentation and $G_{93}CNF_7$: 93 % *gari*: 7 % cowpea hull added after fermentation.

	Addition as a %	
Treatment	***Gari* (G)**	**Cassava (C)**
G_{100}	100	-
$G_{97}CF_3$	97	3
$G_{95}CF_5$	95	5
$G_{93}CF_7$	93	7
G_{100}	100	-
$G_{97}CNF_3$	97	3
$G_{95}CNF_5$	95	5
$G_{93}CNF_7$	93	7

NB: From factorial design, two 100 % cassava exists which was treated as one, resulting in seven samples instead of eight.

Production of cowpea hull-enriched *gari*

Traditional method described by Abass et al., (2013) was adopted for producing *gari* enriched with cowpea hull (EG). The freshly harvested cassava roots were peeled manually with the use of sharp stainless steel knife. This was carried out as thoroughly as possible to ensure no fragment of red peel remained. Peeled roots were washed thoroughly in potable water to remove soils, dirt and other extraneous materials that might be present from the peeling operation. Thereafter, the peeled cassava roots were grated into a smooth mash with the aid of a diesel-powered locally fabricated motorized grater. The grated cassava mashes were packed into porous jute bags, tied and left to ferment for 5 days for control samples. After fermentation, the cassava mashes, while still in the jute bags, were pressed in a hydraulic press for few hours. Then for the other mash in a separate jute bags, prepared and weighed cowpea hulls were added before and after fermentation. The resulting wet cassava cakes obtained following dewatering were broken with hands and sieved through a hand-woven sieve to remove fibrous materials and lumps. The process is followed with roasting in an earthen ware over wood fire until the material is dry enough as signaled by creamy colour and crispy hand-feel. The *gari* samples obtained were allowed to adequately cool at room temperature for

about 6 h before being packaged in polyethylene packs and labeled accordingly for subsequent analyses.

Determination of proximate composition in cowpea hull-enriched *gari*

Proximate compositions of the EG with cowpea hull were determined using the method of Association of Organic Analytical Chemists (AOAC, 2005). The NFE was estimated by the subtracting the summation of crude protein value, crude fibre, ether extract and ash from 100. The metabolizable energy was calculated using the equation of Pauzenga (1985) as indicated in the equation below:

Metabolizable energy (kcal/kg DM) = 37x % protein + 81.8 x % fat + 35.5 x % NFE

Determination of minerals in cowpea hull-enriched *gari*

The mineral contents of EG were determined as described by AOAC (2000). The EGs were digested by concentrated nitric acid and sulfuric acid (3:1, v/v). Digestion tubes (500 ml) were labelled per sample as well as for the reagent blank (control). One hundred (100 g) gram of each EG was weighed and placed in a digestion tube. The EG were prepared in triplicates. Five ml concentrated nitric acid was pipetted into each tube. The tubes containing the samples and the reagent blank were set in a digestion block (HYP-308, Shandong, China). The digestion block was turned on and set at 175 °C to start the pre-digestion. The samples were swirled gently twice during the nitric acid pre-digestion, using tongs and protective gloves. The tubes were removed from the digestion block when brown gas started to elute or when solution begins to steam and placed in the cooling rack. Pre-digested samples were allowed to cool for at least 30 min and 4 ml of 30% hydrogen peroxide to each tube was added and gently swirled. The tubes were placed back in the digestion block and the digestion block was turned on and set at 175 °C. Thereafter, the tubes were closely watched for the start of reaction, indicated by the appearance of rolling bubbles. As soon as the reaction started, the tubes were removed from the block and the reaction continued in the cooling rack. The same procedure was repeated for all the samples and the reagent blank. The tubes were placed back in the digestion block (second phase of digestion) and left until ca. 1–1.5 ml remains, and then removed from the digestion block. The tubes were checked every 10–15 min during this digestion to avoid drying off. Upon attainment of (1–1.5), the tubes were removed cooled. Then, 2 ml concentrated nitric acid was added and continued heating sustained. The digestion block was turned off when all the tubes have been digested and then removed. The samples were filtered using Whatman hardened ashless #540 filter paper into container appropriate for analysis by AAS. For example for sodium (Na) quantification using AAS, ashed sample was diluted with distilled water to 25 ml, then 0.2 ml diluted to 100 ml. The minerals (Ca, Na, Zn, Mg, K and Fe) were estimated using an atomic absorption spectrophotometer (210, Buck Scientific USA). Phosphorus (P) was measured by converting phosphates into phosphorus molybdenum blue pigment and measured at 700 nm.

Determination of amino acids in cowpea hull-enriched *gari*

The method described by AOAC (2005) with modifications was used. The sample was dried at 70°C to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the applied biosystems PTH amino acid analyzer (Model 120A Lincoln). The sample was defatted using chloroform/methanol mixture of ratio 2:1. About 4g of the sample was put in an extraction thimble or wrapped in a filter paper and extracted for 15 hours in soxhlet extraction apparatus. The nitrogen of protein and other compounds were converted to ammonium sulphate by acid digestion with boiling Sulphuric acid. A known weight of sample (250mg) is placed in Kjeldahl flask and about 200 milligram of catalyst mixture (potassium sulphate, copper sulphate and selenium powder) is added. Then, 10.0cm^2 of concentrated Sulphuric acid was added to the content of the flask. It was heated gently for few minutes until frothing ceases and increase the heat to digest for 1 hour 30minutes after which it was cooled and make up to a known volume with distilled water (100cm^3). After which 10.0cm^3 aliquot of the dilute solution of the digest was distilled by pipetting the volume into distillation chamber of micro Kjeldhal distillation apparatus. Then 10.0cm^3 of 40% sodium hydroxide solution and steam distil into 10.0cm^3 of 4% boric acid containing mixed indicator was titrated with standard 0.01N or 0.02N hydrochloric acid to grey end point.

$$\% N = \frac{(a-b) \times 0.01 \times 14.0057 \times c \times 10}{d \times e}$$

a = Titre value for the sample

b = titre value for the blank

c = Volume to which digest is made up with distilled water

d = Aliquot taken for distillation

e = Weight of dried sample (mg)

Hydrolysis of the sample was carried out by weighing a known weight of the defatted sample was weighed into glass, 7ml of 6N HCl was added and oxygen was expelled by passing nitrogen into the ampoule (this is to avoid possible oxidation of some amino acids during hydrolysis e.g methionine and cystine). The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at 105^{0}C± 5°C for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. The filtrate was then evaporated to dryness using rotary evaporator. The residue was dissolved with 5ml to acetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer.

The hydrolysate was loaded into the amino acid analyzer. The amount loaded was 60 µl. This was dispensed into the cartridge of the analyzer. The analyzer is designed to separate and analyze free acidic, neutral and basic amino acids of the hydrolysate. An integrator attached to the Analyzer calculates the peak area proportional to the concentration of each of the amino acids.

Analysis of vitamins in cowpea hull-enriched *gari*

Determination of vitamin B-complexes

The vitamin B group (niacin, panthotenic acid, riboflavin) was extracted according to a previously described method of AOAC (2000). In brief, *gari* samples (2 g) was placed in 25 mL of H_2SO_4 (0.1 N) solution and incubated for 30 min at 121 °C. Then, the contents were cooled and adjusted to pH 4.5 with 2.5 M sodium acetate, and 50 mg Takadiastase enzyme was added. The preparation was stored at 35 °C overnight. The mixture was then filtered through a Whatman No. 4 filter, and the filtrate was diluted with 50 mL of pure water and filtered again through a micropore filter (0.45 μm). Twenty microliters of the filtrate was injected into the HPLC system. Quantification of vitamin B content was accomplished by comparison to vitamin B standards.

Standard stock solutions for niacin, panthotenic acid, riboflavin were prepared as reported previously by Aslam et al., 2008). Chromatographic separation was achieved on a reversed phase- (RP-) HPLC column (Agilent ZORBAX Eclipse Plus C18; 250 × 4.6 mm i.d., 5 μm) through the isocratic delivery mobile phase (A/B 33/67; A: MeOH, B: 0.023 M H_3PO4, pH = 3.54) at a flow rate of 0.5 mL/min. Ultraviolet (UV) absorbance was recorded at 270 nm at room temperature (Marzougui *et al*., 2009).

Determination of ascorbic acid

Vitamin C was extracted according to a modification of a published method (Babarinde, 2012). The EG was blended and homogenized with an extracting solution containing metaphosphoric acid (0.3 M) and acetic acid (1.4 M). The mixture was placed in a conical flask and agitated at 10,000 rpm for 15 min. The mixture was then filtered through a Whatman No. 4 filter, and samples were extracted in triplicate. The ascorbic acid standard was prepared by dissolving 100 mg of l-ascorbic acid in a metaphosphoric acid (0.3 M)/acetic acid (1.4 M) solution at a final concentration of 0.1 mg/ml. The calibration line was converted to a linear range based on four measured concentration levels. Quantification of ascorbic acid content was performed on an Agilent HPLC system. Chromatographic separation was achieved on an RP-HPLC column through isocratic delivery of a mobile phase [A/B 33/67; A: 0.1 M potassium acetate, pH = 4.9, B: acetonitrile: water (50:50)] at a flow rate of 1 mL/min. UV absorbance was recorded at 254 nm at room temperature.

Determination of fat-soluble vitamins

Vitamin K and β-Carotene analyses of *gari* samples were determined. In 10 g of EG, 1 g of pyrogallic acid, 70 mL ethanol, and 30 mL (50%) KOH were added, stirred, and refluxed for 40 min using a water bath at 50±2 °C (Jun et al., 2007). Extracts were obtained three times using various ether concentrations (50 mL, 30 mL, and 20 mL). Double-distilled water was used to neutralize the extract, which was dehydrated using anhydrous sodium sulfate. Further, the extract was concentrated to approximately 5 mL by using a water bath (50 ± 2°C), diluted to 10 mL by using methanol, filtered using a 0.45 μm membrane, and finally subjected to HPLC analysis. RP-HPLC analysis was performed with the Agilent 1100 series HPLC system (Agilent; USA), including a diode array detector. The column was made of stainless steel. For β- carotene quantification, the Agilent TC-C18 column was used (5 μm, 4.6 × 250 mm) with an acetonitrile-methyl alcoholethyl acetate (88:10:2) solvent, and UV absorbance was recorded at 453 nm. For fat-soluble vitamins, the Agilent Eclipse XDB-C18 column was used (5 μm, 4. 6 × 150 mm).

Determination of hydrogen cyanide, total titratable acidity and pH contents in cowpea hull-enriched *gari*

Determination of cyanide content

The method of AOAC, (2005) was used. Each (4 g) of the EG was soaked in a solution containing 40 ml of distilled water and 2 ml of orthophosphoric acid. This was kept overnight at room temperature. Distillation apparatus was set and the sample was distilled. The distillate (5 ml) was collected into a receiving flask containing 40 ml of distilled water and 0.1 g of sodium hydroxide pellet. The obtained mixture was transferred into a 50 ml volumetric flask and made up to mark with distilled water. An aliquot (20 ml) of this was then measured and transferred into a conical flask after which 1.6 ml of 5% KI was added. The resulting mixture was titrated against 0.01 M $AgNO_3$.

Cyanide content (mg / kg) = 13.5 ($V_1 - V_0$) x M

Where V_0 = titrate for sample

V_1 = titre value

M = mass of the sample

Determination of pH

The pH of the EG was determined using the method of AOAC (1990). Each EG (10 g) was put into 100 ml beaker and 100 ml of distilled water was added. This was allowed to stay for a few minutes after which it was filtered with a whatman filter paper. The filtrate was then taken and tested using a standardized pH meter. Triplicates values were obtained, the means of which were then calculated.

Determination of total titratable acidity (TTA)

The percent titratable acidity was determined using the method described by FAO (1970). Each EG (5 g) was dissolved in a beaker and made up to 100 ml mark with distilled water, then allowed to stand for 30 min. The solution was filtered with Whatman filter paper. The filtrate (25 ml) was taken and titrated against 0.1 M NaOH, using phenolphthalein as the indicator. The end point was obtained when the colour became pink. The mean (TTA) was then calculated from triplicate values.

The Percent Titrable Acidity (TTA %) was calculated using the formula:

TTA (%) = 0.005X x 100 x 1000 = 0.01x

X is the mean titre value.

Determination of anti-nutritional properties in cowpea hull-enriched gari

Trypsin inhibitor activity

The Method described by Kakade et al., (1974). Tris-buffer (0.05 M, pH 8.2) containing 0.02 M CaCl2: 6.05 g tris-

(hydroxymethy) aminomethane (from Sigma Chemical Co.) and 2.94 g $CaCl_2.2H_20$ dissolved in 500 ml of distilled water. The pH was adjusted to 8.2 and the volume made up to 1L with distilled water and 40 mg of benzoyl-DL-arginine-P-nitroanilide (BAPA) hydrochloride (Sigma Chemical Co) were dissolved in 1 ml of dimethyl sulphoxide (BDH) and diluted to 100 ml with tris-buffer pre-warmed to 37°C. The BAPA solution was prepared daily and kept at 37°C while in use. Then, 4 mg of accurately weighed trypsin (crystalline, salt free) (Sigma Chemical co) was dissolved in 200 ml 0.001 M HCI. The solution was stored in the refrigerator. 1 g of sample was extracted with 50 ml of 0.01 M NaOH. The extraction time was 3 h for the samples. The pH of the suspension was usually 9.5 to 9.8. The processed sample extracts was diluted to 1:10 with distilled water. Portion (0, 0.6, 1.0, 1.4 and 1.8 ml) of diluted sample suspensions were pipetted into duplicate sets of test tubes and adjusted to 2 ml with distilled water. After 2 ml of trypsin solution had been added to each test tube, the tubes were placed in a water bath at 37°C. To each tube, 5 ml of BAPA solution previously warmed at 37°C were added, and exactly 2 min later, the reaction was terminated by adding 1 ml of 30% acetic acid. After thorough mixing, the contents of each tube were filtered (Whatman No. 54`) and the absorbance of the filtrate was measured at 410 nm against a reagent blank. The reagent blank was prepared by adding 1 ml of 30% acetic acid to a test tube containing 2 ml each of trypsin solution and 2 ml distilled water, followed by the addition of 5 ml BAPA solution. Calculation of trypsin inhibitor unit in calculating the result, one trypsin unit (TIU) was arbitrarily defined as an increase of 0.01 absorbance units at 410 nm per 10 ml of the reaction mixture under the condition described here.

Phytate content

Phytate content was determined using Wade's reagent colorimetric method described by Latta & Eskin, (1980). One gram (1g) of the EG was mixed with 20 mL of hydrochloric acid (0.65 N) and stirred for 12 h with a magnetic Stirrer. The mixture was centrifuged at 12000 rpm for 40 min. An aliquot (0.5 mL) of supernatant was added with 3 mL of Wade's reagent. The reaction mixture was incubated for 15 min and absorbance was measured at 490 nm by using a spectrophotometer (PG Instruments, England). Phytate content was estimated using a calibration curve of sodium phytate (10 mg/mL) as standard.

Total phenols content

The total phenolic content was determined according to the Folin-Denis method (Singleton et al., 1999) with modifications. A volume of 100 µL garri extract was mixed with 50 µL Folin-ciocalten's reagent (Sigma-Aldrich Co., St. Louis, USA) and 300 µL 2% Na_2CO_3. After being kept for 15 min, 1 mL of distilled water was added and the absorbance was measured by spectrophotometry (UV-2550, Shimazu Co., Tokyo, Japan) at 725 nm. The result was expressed as mg gallic acid eq. per g (mg GAE/g).

Sensory evaluation of cowpea hull-enriched *gari*

A multiple paired comparison test was used for the sensory evaluation of the EG in its dry particulate, soaked, and cooked paste forms. A 50 member-panel comprising staff and students of the department of Home Economics and Food Science, University of Ilorin, who are familiar with the quality of *gari* were selected for this purpose. Prior to the evaluation, panelists were screened by their interest to participate and their ability to discern sensory quality.

Parameters assessed on the EG in their dry particulate form include colour, aroma, mouth feel, texture and overall acceptability while colour, aroma, mouth feel, texture, mouldability and overall acceptability were determined for the cooked dough (*eba*) samples. The EGs were made into cooked dough (*eba*) by reconstituting 180 g into 500 ml of boiling water and were assessed. All parameters were assessed on a 9-point hedonic scale of preference, with 1 and 9 representing 'dislike extremely' and 'like extremely', respectively.

Statistical analysis

Results of the analyses described above were subjected to Analysis of Variance (ANOVA) to determine significant differences, and the means were separated with Duncan Test, using Statistical Package for Social Sciences (SPSS), version 20.0.

RESULTS AND DISCUSSION

Proximate composition of cowpea hull-enriched *gari*

The result of proximate composition of EG is presented in Table 2. The enrichment and fermentation were observed to have a significant effect ($p<0.05$) on the EG. Moisture and crude fat value decreased with increasing level of inclusion while crude fibre and crude protein increased with increasing level of inclusion. Moisture content was significantly ($p<0.05$) affected by the processing method and inclusion level. Sample G_{100} (100 % *gari* without enrichment) had the highest moisture content (8.26 %) followed by $G_{97}CNF_3$ (97 % *gari* and 3 % hull added after fermentation) while $G_{95}CF_5$ (95 % *gari* and 5 % hull added before fermentation) recorded lowest value (6.03 %). The decrease in moisture contents of the enriched samples may be due to the inclusion of cowpea hulls which has low moisture content compared to the control samples which is made from 100 % cassava mash and could also be due to increased dry matter content as a result of microbial cell proliferation (Akanbi et al., 2009). The available moisture in the sample depends to a large extent on the degree of dryness during roasting. Moisture content of food or processed food products shows how long the food will stay (shelf life). High moisture content enhances microbial growth, thereby contaminating the food and reducing its quality and stability (Akanbi et al., 2009). The value obtained in this report was lower compared to the 13 % value recommended for *gari* (FAO, 2006). But higher than 0.54 to 6.96 % reported by Ogunlakin *et al*, (2015) for soy *gari*.

The fat content of the EG increased significantly ($p<0.05$) from 1.02 % for control sample to 1.44 % ($G_{93}CNF_7$: Cowpea hull added after fermentation at ratio 7%: 93% *Gari*). The value obtained in this study is lower compared to 1.34 to 5.74 % reported by Karim et al., (2015) for soy-

melon-okro gari and 1.29 to 5.20 % for soy-gari reported by Ogunlakin et al., (2015). The increased value from previous research could be as a result of the use of whole seed which compared to cowpea hulls used in this study. The low fat content noticed in the samples that had the hulls added before fermentation when compared to those that the hulls are added after fermentation could be as a result of leaching of nutrients from the water that ooze out of the mash during pressing and might also be attributed to the increased activities of the lipolytic enzymes during fermentation which hydrolyses fat components (triacylglycerol) into fatty acid and glycerol (Obadina et al., 2009). Different authors like Astuti et al., (2000) reported the usage of fatty acids as sources of energy by some microorganisms such as moulds resulting in lower fat content in fermented *gari* enriched with cowpea hull and increased fat content in the unfermented counterparts. Fat content in flour or granular samples explains its storability due to various chemical reactions associated with lipid oxidation (Savage et al., 2002). The result therefore indicates that the *gari* sample with the lowest fat content is likely to store longer than others. But, fat serve as energy store in the body when it is broken down to release glycerol thereafter converted by the liver into glucose (energy). It has been reported that 1g of fat provides 9Kcal of energy (Gaman & Sherrington, 1990).

The crude fibre ranged between 2.02 to 3.01 % with control sample having the lowest value (2.02 %) and $G_{97}CNF_3$ (Cowpea hull added after fermentation at ratio 3%: 97% *gari*) had the highest value (3.01 %). The samples show significant difference ($p<0.05$). These values compared well with values recorded for crude fibre content of soy-melon *gari* obtained by Oluwamukomi et al., (2007) who reported 2.40 to 6.80 % but higher than the value (2.00 to 2.16 %) and (1.73 to 2.11 %) reported by Ogunlakin et al., (2015) for soy-gari and Karim et al., (2015) respectively. Fibres aid in digestive processes lowers the vitamin and enzyme content of the food material (Alaise & Linden, 1999). All the enriched *gari* sample shows good values for crude fibre which reveals that they are rich in insoluble dietary fibre. The high value recorded can be attributed to the crude fibre content of the cowpea hull.

Ash content ranged between 1.32 to 1.74 % with $G_{95}CF_5$ (Cowpea hull added before fermentation at ratio 5%: 95% *gari*) having the highest ash content (1.74 %), while the control sample containing 100% *gari* had the lowest value (1.32 %). There was significant ($p<0.05$) difference among the EG. The value obtained in this study is lower compared to 1.55 to 2.47 % obtained from soy-melon *gari* reported by Alozie & Ekerette (2017) and Karim et al., (2015). But greater than 1.29 to 1.46 % reported by Ogunlakin et al., (2015) for groundnut-coconut *gari* and soy-*gari* respectively. Fermentation had a marked effect on the ash content because the samples where cowpea hull is added before fermentation had higher ash content than their unfermented counterpart. The higher ash content of fermented cowpea hull samples could be due to activities of fermenting micro-organism in the breakdown of organic components and the reduction of certain chemical components such as carbohydrate, moisture and fat. The ash in food refers to the inorganic content residue remaining after the organic matter has been burnt and it contributes to the nutritional quality of food products which also give an idea of the mineral elements present in the food.

The protein content of the EG samples was significantly high. From the result, the fermentation significantly affected the EG that has cowpea hulls fermented with them. The highest value (5.01 %) was obtained in *gari* sample $G_{93}CF_7$ (Cowpea hull added before fermentation at ratio 7%: 93% *Gari*) while the control sample G_{100} (100 % *gari*) had the lowest value (2.07 %). The variation in protein content observed in the samples may be due to the effects of addition of cowpea hulls at different ratios and the inclusion levels. In the presence of atmospheric oxygen, protein contained in food substances tend to reacts forming several intermediates which make the amino group of the amino acids non bio-available also increased protein content can be as a result of the increased activities of hydrolytic enzymes, degradation of storage protein and synthesis of new protein during fermentation could have caused this increase (Wiriya et al., 2009; Inyang & Zakari, 2008). The protein content of EG is evident from the high protein value (14.77 %) reported in this study and (14.11 to 16.71 %) reported by Adebiyi et al., (2015) for cowpea hull. Fermentation has been implicated as best processing method/techniques that can improve the level of protein in legumes by different authors to cause increasing protein content of legume-based products which could be beneficial in supplementing/fortifying/enriching the nutrients obtained from other food crops such as cassava which is low in protein and assisting people suffering from protein deficiency related diseases (Kumitch 2019; Curiel et al., 2015).

Nitrogen free extract or carbohydrate contents of all the EG ranged from 82.85 to 85.32 % with $G_{93}CF_7$ (Cowpea hull added before fermentation at ratio 7%: 93% *Gari*) and control G_{100} (100 % *Gari*) had the highest value (85.32 %) due to lack of protein supplement. Significant differences ($p<0.05$) exist in the entire sample. The value obtained is similar to 73.59 to 92.95 % and 77.02 to 84.74 % for soy-*gari* and soy-melon gari (Ogunlakin et al., 2015; Karim et al., 2015) respectively.

The dry matter content of the EG samples ranged from 91.74 to 93.97 % with the control sample G_{100} (100 % *Gari*) having the lowest value (91.74 %) and $G_{95}CF_5$ (Cowpea hull added before fermentation at ratio 5%: 95% *Gari*) having the highest value (93.97 %). Dry matter content was significantly ($p<0.05$) affected by inclusion of cowpea hull at different processing levels. The EG that have the cowpea hulls fermented with the cassava mash had high dry matter content than their unfermented counterpart. This could be attributed to the activities of fermentation which would have led to break down of high molecular weight components like fibre to relatively lower molecular weight simple sugars and the higher fibre fractions of the cowpea hulls. Dry matter is the remaining nutrients in food most especially hulls, feed and fresh or dry forage after all the water is evaporated.

The metabolizable energy (M.E) is the net energy

remaining after urinary and faecal energy loss. It is the energy available for reproduction, growth and metabolic processes like locomotion, maintenance of body tissues and respiration (Encyclopedia, 2009). The inclusion of the cowpea hull significantly ($p<0.05$) affect the M.E as the EGs had higher value than the control sample without the cowpea hull. M.E ranged from 3144 to 3206 kcal/kg. The control sample had the lowest value (3144 kcal/kg) while $G_{95}CF_5$ (Cowpea hull added before fermentation at ratio 5%: 95% *gari*) had the highest value (3206 kcal/kg).

Mineral Content of cowpea hull-enriched *gari*

Enrichment caused a significant ($p<0.05$) increase in the mineral content. Results of the mineral contents (mg/100g) showed that sample $G_{93}CF_7$ (Cowpea hull added before fermentation at ratio 7%: 93% *gari*) and $G_{93}CNF_7$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*) had calcium contents of 5.03 mg/100g while $G_{97}CNF_3$ (Cowpea hull added after fermentation at ratio 3%: 97% *gari*) had the least score 4.02 mg/100g. The value obtained is greater than 2.42 to 3.05 mg/100g for soy enriched *gari* reported by Ogunlakin et al. (2015) but lower than 4.75 to 9.42 mg/100g and 41.55 to 119.52 mg/100g obtained by Owuno et al. (2021) and Oluwamukomi & Adeyemi (2015) for *gari* fermented with yellow maize residue whole soy-enriched *gari* respectively. Calcium is important in the body as it helps to build and maintain bones and teeth. Processing like fermentation has been reported to reduce calcium oxalates (which binds calcium in foods) and its ability to leach in water during fermentation, steeping, soaking etc. (Karim et al., 2017). Therefore, calcium content is increased by fermentation as evident from the report of Oyewole & Odunfa (1989) and result of this study (Table 3).

The addition of cowpea hulls caused a significant ($p<0.05$) increased in the sodium (Na) contents of the EG samples. As the levels increased sodium contents increased for both fermented and non-fermented samples. Sodium content ranged from 4.26 to 6.02 mg/100g. The control and sample $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) had the lowest value (4.26 mg/100g) while $G_{93}CF_7$ (Cowpea hull added before fermentation at ratio 7%: 93% *gari*) had the highest value (6.02 mg/100g). The result obtained is closely related to 4.50 to 13.35 mg/100g recorded by Samuel et al. (2012) for soy-enriched tapioca. Sodium is a primary electrolyte in body fluids required for regulating blood flow which is required in the formation of enzymes (Enyiukwu et al., 2018). Whelton & He (2014) opined that consumption of high sodium food could lead to osteoporosis and a lot of diseases such as cardio-vascular diseases on the long run. The result obtained is favourable as WFP (2012) recommended lower amount of sodium for people living with liver cirrhosis, congestive heart failure, liver and kidney disease due to the inability of the kidney to excrete the mineral in high doses causing buildup of fluid in tissues.

The value of zinc detected for the EG ranged from 0.22 to 0.42 mg/100g. $G_{93}CF_7$ (Cowpea hull added before fermentation at ratio 7%: 93% *gari*) had the lowest value (0.22 mg/100g) while $G_{93}CNF_7$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the highest (0.42 mg/100g) value. The result obtained showed that fermentation greatly reduced the zinc content and value is slightly lower than 0.05 to 1.24 mg/100g reported by Owuno et al. (2021) for gari fermented with maize residue. Findings show that 8-11 mg/day is recommended daily for adolescents and 12-19 mg/day for adults (Idris, 2011). In the body tissues zinc is needed for healthy cell division. It acts as an antioxidant, fighting free radicals and slowing the aging process. This nutrient is needed in production of progesterone, estrogen and testosterone which could affect menstruation, cause early menopause in healthy individuals, hinders diabetes by binding insulin thereby making the biochemical to be stored in the pancreas and released only when glucose enters the blood stream, chronic fatigue, common cold and diarrhea (Axe, 2016).

Magnesium, a macro-mineral which is essential in the body system was also detected at 3.03 to 4.07 mg/100g in this study. Enrichment of the *gari* with cowpea hulls and fermentation significantly ($p<0.05$) affects the magnesium contents of the samples. The magnesium contents decreased as the cowpea hull increased in the EG that had their hulls fermented with the cassava mash and decreased as cowpea hull increased in the unfermented counterpart. The report of this study is significantly superior to the range 2.50 to 3.20 mg/100g reported by Owuno et al. (2021) for *gari* fermented with maize residue. Magnesium is important In the metabolism of carbohydrates, regulates vital energy processes, blood sugar levels by improving insulin production and sensitivity thereby reducing Type-2

Table 2: Proximate composition of cowpea hull-enriched *gari.*

Sample	Moisture (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Crude protein (%)	Nitrogen free extract (%)	Dry matter (%)	M.E (Kcal/kg)
G_{100}	$8.26^{a}\pm0.00$	$1.02^{d}\pm0.01$	$2.02^{f}\pm0.00$	$1.32^{e}\pm0.00$	$2.07^{g}\pm0.02$	$85.32^{a}\pm0.01$	$91.74^{f}\pm0.00$	$3144^{d}\pm0.36$
$G_{97}CF_3$	$7.55^{b}\pm0.00$	$1.42^{a}\pm0.00$	$2.32^{e}\pm0.01$	$1.65^{b}\pm0.01$	$3.47^{e}\pm0.03$	$83.59^{c}\pm0.03$	$92.45^{d}\pm0.00$	$3168^{c}\pm0.25$
$G_{95}CF_5$	$6.03^{e}\pm0.00$	$1.41^{a}\pm0.01$	$2.65^{d}\pm0.00$	$1.74^{a}\pm0.01$	$4.13^{c}\pm0.01$	$84.04^{b}\pm0.04$	$93.97^{a}\pm0.00$	$3206^{a}\pm0.14$
$G_{93}CF_7$	$6.50^{d}\pm0.00$	$1.23^{c}\pm0.01$	$2.86^{b}\pm0.01$	$1.56^{c}\pm0.01$	$5.01^{a}\pm0.01$	$82.85^{e}\pm0.01$	$93.51^{b}\pm0.00$	$3180^{b}\pm0.74$
$G_{97}CNF_3$	$7.62^{b}\pm0.00$	$1.31^{b}\pm0.00$	$3.01^{a}\pm0.00$	$1.44^{d}\pm0.01$	$3.11^{f}\pm0.00$	$83.50^{c}\pm0.01$	$92.38^{e}\pm0.00$	$3143^{d}\pm1.10$
$G_{95}CNF_5$	$7.13^{c}\pm0.00$	$1.42^{a}\pm0.01$	$2.75^{c}\pm0.01$	$1.64^{b}\pm0.01$	$3.68^{d}\pm0.05$	$83.39^{d}\pm0.10$	$92.87^{c}\pm0.00$	$3168^{c}\pm0.53$
$G_{93}CNF_7$	$7.13^{c}\pm0.00$	$1.44^{a}\pm0.01$	$2.76^{c}\pm0.01$	$1.65^{b}\pm0.01$	$4.34^{b}\pm0.00$	$82.73^{f}\pm0.04$	$92.87^{c}\pm0.00$	$3172^{c}\pm5.59$

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

diabetes by 15%, support healthy immune system, helps in protein synthesis, heart rhythm steady, maintaining healthy cells, promote strong bones and normal blood pressure (Enyiukwu, 2018).

The addition of cowpea hull increased the potassium contents from 2.75 to 4.52 mg/100g. The potassium level increased as level of cowpea hull increased. However, fermentation reduced the level of potassium in the EG that has their hulls fermented with the cassava mash during the production of the *gari*. $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) had the lowest value (2.75 mg/100g) while $G_{93}CNF_7$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the highest value (4.52 mg/100g). Potassium is macro-mineral which is highly essential in the body system, present in the range of 528-650 mg in foods such as whole beans, grains and many vegetables (Enyiukwu, 2018). The low potassium content reported in this study is because the hulls of the cowpea are used compared to whole legume or grain seed. Ware and Carter, (2018) reported that potassium helps reduced risk of strokes, regulates body fluids, counteracts the effects of sodium to maintain healthy blood pressure, maintain balance between acid and base in the body.

Phosphorus is an essential micronutrient useful for bone metabolism its deficiency may cause bone diseases such as osteomalacia and rickets in adults and children respectively (Gutierrez, 2020). The phosphorus contents ranged from 4.02 mg/100g for $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% gari) to 5.04 mg/100g for $G_{97}CNF_3$ (Cowpea hull added after fermentation at ratio 3%: 97% gari). The result obtained in this study is slightly higher than (4.04 to 4.67 mg/100g) recorded by Owuno et al., (2021) for gari fermented with maize residue. But, lower than 49.62 to 69.54 mg/100g and 16.20 to 18.62 mg/100g for soy-*gari* and Soy-melon enriched *gari* respectively (Ogunlakin *et al*., 2015; Oluwamukomi & Adeyemi, 2015). The low phosphorus content recorded in this study might be due to the fact that the cowpea hulls are used in this study compare to full whole grains used by other authors and the phosphorus content in soybean is also high than cowpea.

Iron is a major component of hemoglobin which helps in transporting oxygen to all parts of the body. The iron contents of the cowpea hulls enriched samples ranged from 0.21 to 0.31 mg/100g. Significant ($p<0.05$) difference exist among the samples. $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) had the lowest value (0.21mg/100g) while $G_{93}CF_7$ (Cowpea hull added before fermentation at ratio 7%: 93% *gari*) had the highest value (0.31 mg/100g). Fermentation slightly caused an increased in the iron contents of the fermented cowpea hulls samples. The result is superior than (1.43 to 1.77 mg/100g) recorded by (Ogunlakin et al., 2015) for soy-gari but lower than (5.70 to 8.88 mg/100g) reported by Owuno et al., (2021) for gari fermented with maize residue. The high scored obtain by other authors can be as a result of different crops used, variation in geographical and soil conditions as opined by (Zakpaa et al., 2010).

Amino acid profile of cowpea hull-enriched *gari*

The amino acids contents of the EG is shown in Table 4. The quality of protein through its building block (amino acids) has been considered one of the important characteristics for measuring the nutrients of food samples. The results of the amino acid profile in this study revealed that EGs had high amino acid contents compared to the control. The formulations contain all the essential amino acids. The amino acid profiles of the food samples showed that glutamic acid had the highest concentration with values from 3.04 g/100 g protein in the control sample to 7.67 g/100 g protein in $G_{93}CNF_3$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*) while tryptophan is the most limiting ranging from 0.11 g/100 g protein in control to 0.43 g/100 g protein in $G_{93}CNF_3$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*). Various studies have shown that cereals, roots and tuber-based foods constitute the main staples for the world populations (Oniang'o et al., 2003). Research has also shown that most local foods like gari have poor protein and essential amino acids (Fasuan et al., 2018) and most of the world poorest households consume products from this crop without any accompaniment that is rich in protein resulting to Protein-energy malnutrition (PEM), implicated for the high prevalence of morbidity and mortality, most especially among the children and mothers (Daelmans & Saadeh, 2003). Efforts have been made by different organization to prevent this menace, such as enrichment, fortification and restoration of locally available food by the Integrated Child Development Scheme (ICDS) and Food and Agriculture

Table 3: Mineral contents (mg/100g) of cowpea hull-enriched *gari*.

Samples	Ca	Na	Zn	Mg	K	P	Fe
				(mg/100g)			
G_{100}	$4.16^{f}\pm0.00$	$4.26^{f}\pm0.00$	$0.26^{c}\pm0.00$	$3.13^{f}\pm0.00$	$3.22^{d}\pm0.00$	$4.15^{e}\pm0.00$	$0.24^{d}\pm0.00$
$G_{97}CF_3$	$4.26^{e}\pm0.00$	$4.26^{f}\pm0.00$	$0.31^{b}\pm0.00$	$4.22^{a}\pm0.00$	$2.75^{g}\pm0.00$	$4.02^{g}\pm0.00$	$0.21^{f}\pm0.00$
$G_{95}CF_5$	$4.47^{c}\pm0.00$	$4.52^{e}\pm0.00$	$0.23^{e}\pm0.00$	$3.51^{c}\pm0.00$	$3.06^{f}\pm0.00$	$4.21^{d}\pm0.00$	$0.26^{c}\pm0.00$
$G_{93}CF_7$	$5.03^{a}\pm0.00$	$6.02^{a}\pm0.00$	$0.22^{g}\pm0.00$	$3.15^{e}\pm0.00$	$3.13^{d}\pm0.00$	$4.35^{c}\pm0.00$	$0.31^{a}\pm0.00$
$G_{97}CNF_3$	$4.02^{g}\pm0.00$	$5.02^{c}\pm0.00$	$0.23^{f}\pm0.00$	$3.03^{g}\pm0.00$	$4.12^{c}\pm0.00$	$5.04^{a}\pm0.00$	$0.21^{f}\pm0.00$
$G_{95}CNF_5$	$4.32^{d}\pm0.00$	$5.01^{d}\pm0.00$	$0.25^{d}\pm0.00$	$3.42^{d}\pm0.00$	$4.26^{b}\pm0.00$	$5.02^{b}\pm0.00$	$0.22^{e}\pm0.00$
$G_{93}CNF_7$	$5.03^{a}\pm0.00$	$5.62^{b}\pm0.00$	$0.42^{a}\pm0.00$	$4.07^{b}\pm0.00$	$4.52^{a}\pm0.00$	$4.11^{f}\pm0.00$	$0.26^{b}\pm0.00$

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

Organization (FAO). Methionine is the most limiting amino acids in the EG followed by histidine. The EG that have their hulls not fermented ($G_{97}CNF_3$, $G_{95}CNF_5$, $G_{93}CNF_3$) had high amino contents than those that are fermented ($G_{97}CF_3$, $G_{95}CF_5$, $G_{93}CF_7$) which is contrary to earlier report of Jannathulla et al., (2017); Cui et al., (2012) who opined that fermentation caused an increase in amino acid contents of food samples. The reduced score in the fermented hulls samples might be as a result of sieving which has caused lost in hulls since some shaft are discarded after sieving thereby reducing the quantity of the hulls.

Vitamins contents of cowpea hull-enriched *gari*

Table 5 shows fat and water soluble vitamins content in mg/100g of EGs. Unit operation such as fermentation significantly ($p<0.05$) affected the contents. The result of the riboflavin (Vitamin B_2) content of the EG ranged from 0.21 to 0.31 mg/100g. Sample $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) had the lowest value (0.21 mg/100g) while $G_{93}CNF_3$ (cowpea hull added after fermentation at ratio 7%: 93% *gari*) recorded the highest value (0.31 mg/100g). The EG that have their cowpea hulls added after fermentation and sieving had increased riboflavin contents than the fermented counterpart. The reduction in the value obtained from the fermented sample may be because riboflavin is a water soluble vitamin which might have leached out during fermentation and discarded during pressing. The result conforms to the report of Fadahunsi (2009) who reported a 6.2 % (from 1.55 to 0.14) reduction in the riboflavin contents of whole Bambara groundnut. Ogumodede & Oyenuga, (1969) reported that brown eye type variety of beans had high value than the black eye with value of (0.14 to 0.29 mg/100g) for whole beans. But negate the report of Phillips et al., (1983) who reported increased riboflavin content for whole cowpea.

A study of the niacin (Vitamin B_3) content revealed that there was no significant difference at ($p<0.05$) in all the EG which shows that fermentation and percentage did not affect the niacin content and ranged from 0.87 to 1.02 mg/100g. The result is slightly lower than the value (1.11 to 1.42 mg/100g) reported by Ogumodede & Oyenuga, (1969) for whole cowpea. According to Institute of Medicine (1998), niacin is a water soluble vitamin which has been reported to help in repairing DNA, converts nutrients into energy and has antioxidant activities. High content in diets has also been implicated for impaired glucose intolerance, dizziness, low blood pressure, blurred vision and inflammation of the liver. Hence, the value obtained in this study is a good one as the value is not too low or high.

Panthotenic (Vitamin B_5) acid content of the EG is negligible and ranged from 0.02 to 0.06 mg/100g. The fermented samples had reduced panthotenic acid than their unfermented counterpart. Whole cowpea seeds have been reported to have negligible value (0.41 mg/100g) of panthotenic acid as reported by FDC, (2019) for whole cowpea. Panthotenic acid is a water soluble vitamin necessary for the synthesis of coenzyme A (CoA): useful in the metabolism of fatty acids, carbohydrates and fats. It deficiency can lead to neurological, immunological and reproductive pathologies (Miller & Rucker, 2012).

Table 4: Amino acid profile of cowpea hull-enriched *gari.*

Amino acid	G_{100}	$G_{97}CF_3$	$G_{95}CF_5$	$G_{93}CF_7$	$G_{97}CNF_3$	$G_{95}CNF_5$	$G_{93}CNF_7$
	(g/100g protein)						
Leucine	$1.41^{g}\pm0.01$	$1.67^{f}\pm0.02$	$1.82^{e}\pm0.01$	$2.07^{d}\pm0.01$	$2.63^{c}\pm0.03$	$2.88^{b}\pm0.03$	$3.05^{a}\pm0.01$
Lysine	$0.53^{g}\pm0.02$	$0.60^{f}\pm0.00$	$0.72^{e}\pm0.01$	$2.13^{d}\pm0.01$	$2.43^{c}\pm0.02$	$2.74^{b}\pm0.02$	$2.93^{a}\pm0.01$
Isoleucine	$0.29^{g}\pm0.01$	$0.35^{f}\pm0.02$	$0.43^{e}\pm0.01$	$1.06^{d}\pm0.01$	$1.48^{c}\pm0.01$	$1.70^{b}\pm0.02$	$2.00^{a}\pm0.01$
Phenyalanine	$0.58^{e}\pm0.01$	$0.67^{d}\pm0.02$	$0.82^{c}\pm0.02$	$1.07^{a}\pm0.01$	$0.64^{d}\pm0.01$	$0.78^{c}\pm0.02$	$0.98^{b}\pm0.02$
Tryptophan	$0.11^{d}\pm0.01$	$0.14^{cd}\pm0.01$	$0.17^{c}\pm0.01$	$0.30^{b}\pm0.01$	$0.27^{b}\pm0.02$	$0.28^{b}\pm0.01$	$0.43^{a}\pm0.01$
Valine	$0.89^{f}\pm0.01$	$0.92^{f}\pm0.01$	$1.01^{e}\pm0.01$	$2.04^{a}\pm0.02$	$1.23^{d}\pm0.01$	$1.36^{c}\pm0.02$	$1.48^{b}\pm0.02$
Methionine	$0.28^{e}\pm0.02$	$0.38^{d}\pm0.02$	$0.47^{c}\pm0.02$	$0.64^{b}\pm0.04$	$0.36^{d}\pm0.04$	$0.67^{b}\pm0.01$	$0.87^{a}\pm0.02$
Proline	$0.65^{e}\pm0.01$	$0.69^{d}\pm0.01$	$0.73^{d}\pm0.02$	$0.53^{f}\pm0.02$	$0.96^{c}\pm0.01$	$1.05^{b}\pm0.02$	$1.24^{a}\pm0.02$
Arginine	$1.44^{g}\pm0.02$	$1.67^{f}\pm0.03$	$1.83^{e}\pm0.03$	$3.20^{b}\pm0.02$	$2.43^{d}\pm0.04$	$3.01^{c}\pm0.02$	$4.65^{a}\pm0.01$
Tyrosine	$1.03^{e}\pm0.03$	$1.15^{d}\pm0.08$	$1.40^{c}\pm0.02$	$2.07^{a}\pm0.01$	$1.20^{d}\pm0.02$	$1.37^{c}\pm0.01$	$1.74^{b}\pm0.02$
Histidine	$0.24^{f}\pm0.02$	$0.37^{e}\pm0.03$	$0.44^{d}\pm0.02$	$0.68^{b}\pm0.01$	$0.42^{de}\pm0.02$	$0.51^{c}\pm0.01$	$0.82^{a}\pm0.02$
Cysteine	$0.87^{e}\pm0.02$	$0.99^{c}\pm0.02$	$1.16^{a}\pm0.01$	$0.92^{d}\pm0.01$	$0.98^{c}\pm0.01$	$1.01^{c}\pm0.01$	$1.10^{b}\pm0.01$
Alanine	$3.02^{f}\pm0.01$	$3.13^{e}\pm0.02$	$3.35^{d}\pm0.01$	$3.09^{e}\pm0.02$	$3.57^{c}\pm0.02$	$3.91^{b}\pm0.02$	$4.33^{a}\pm0.01$
Glutamic acid	$3.04^{g}\pm0.01$	$3.24^{f}\pm0.02$	$3.43^{e}\pm0.03$	$5.17^{d}\pm0.02$	$7.00^{c}\pm0.01$	$7.15^{b}\pm0.01$	$7.67^{a}\pm0.03$
Glycine	$0.57^{e}\pm0.02$	$0.68^{d}\pm0.02$	$0.73^{c}\pm0.02$	$1.04^{b}\pm0.02$	$1.01^{b}\pm0.02$	$1.03^{b}\pm0.01$	$1.34^{a}\pm0.01$
Threonine	$0.93^{c}\pm0.02$	$0.97^{c}\pm0.01$	$1.04^{b}\pm0.01$	$1.52^{b}\pm0.02$	$1.57^{b}\pm0.02$	$1.79^{ab}\pm0.01$	$2.13^{a}\pm0.03$
Serine	$0.52^{d}\pm0.01$	$0.59^{c}\pm0.02$	$0.63^{c}\pm0.01$	$0.55^{d}\pm0.01$	$0.79^{b}\pm0.01$	$0.81^{b}\pm0.02$	$0.95^{a}\pm0.01$
Aspartic acid	$3.35^{c}\pm0.73$	$2.93^{c}\pm0.03$	$3.08^{c}\pm0.01$	$3.34^{c}\pm0.03$	$4.02^{b}\pm0.01$	$4.24^{ab}\pm0.02$	$4.83^{a}\pm0.02$

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

Ascorbic acid also known as Vitamin C of the EG ranged from 4.03 to 7.02 mg/100g. $G_{93}CF_7$ (Cowpea hull added before fermentation at ratio 7%: 93% gari) had the highest value (7.02 mg/100g) and sample G_{100} (cowpea hull 0%: 100% gari) had the lowest score (4.03 mg/100g). The result obtained from this study is low compared to (10.23 to 33.34 mg/100g) reported by Akume et al., (2019), this is not surprising as the *gari* is enriched with mango fruit mesocarp which is highly rich in vitamin C compared to that found in cowpea hull. Enrichment significantly ($p<0.05$) increased the vitamin C content of the *gari* samples. Also, the fermented cowpea hulls samples were found to have higher values than their unfermented counterpart which corroborates with the report of (Oboh et al., 2011; Kusznierewicz et al., 2008) who opined that fermentation caused an increased in the vitamin content of foods. Vitamin C deficiency has been reported to cause immune insufficiency which weakens the body system triggering infection (Yussif, 2018).

Beta carotene (β-carotene) which is a pre-cursor of vitamin A and pigmented red-orange that abounds in plant (Ziegler, 1991). The Beta carotene content ranged from 0.04 to 0.60 mg/100g. The highest value (0.60 mg/100g) was recorded for $G_{95}CNF_5$ (Cowpea hull added after fermentation at ratio 5%: 95% *gari*) while $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) had the lowest value (0.04 mg/100g). The result revealed that enrichment caused an increase while fermentation caused reduction in the β-carotene content of the EG. The result obtained in this study is negligible but greater than the report of Phorbee et al., (2013) that did not found beta-carotene in cassavas used in their study. The result therefore suggest that enrichment of the gari with cowpea significantly ($p<0.05$) affects its β-carotene content.

Vitamin K (phylloquinone) is a fat soluble vitamin require for controlling calcium binding in tissues like bones and post-synthesis modification of proteins utilized during blood clotting (Davie, 1995). There was significant ($p<0.05$) difference between the EG and value ranged from 0.10 to 0.16 mg/100g. The control sample G_{100} (100% *gari*) had the highest value (0.16 mg/100g) and $G_{93}CF_7$ (Cowpea hull added before fermentation at ratio 7%: 93% *gari*) had the lowest score (0.10 mg/100g). The vitamin K content increased as inclusion level increases. Hence, this shows that cowpea hull is rich in Vitamin K.

Hydrogen cyanide, total titratable acidity and pH contents of cowpea hull-enriched *gari*

The enrichment of gari significantly ($p<0.05$) influenced the hydrogen cyanide (HCN), total titratable acidity (TTA) and pH as shown in Table 6. Hydrogen cyanide is a colourless liquid substance which is poisonous and boils at a temperature (25.6 °C) slightly below the room temperature, important in describing the quality and acceptability of *gari* (Gail and Sauer 2005). The result shows that the hydrogen cyanide decreased with increasing cowpea hull. The HCN value ranged from 2.36 to 3.26 mg/kg. The control sample had the highest value (3.26 mg/kg) while sample $G_{93}CNF_7$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the lowest value (2.36 mg/kg) which could be as a result of diluting effects of cowpea hull as opined by Sanni & Sobaniwa, (1994). The HCN values obtained in this study are within the permitted level of 10mg HCN/kg of gari (Adindu et al., 2003) and lower than 6.29 to 6.73 mg/kg, 6.72 to 13.40 mg/kg and 1.20 to 5.00 mg/kg obtained by Karim et al., (2015); Oluwamukomi et al., (2015) & Olatunde et al., (2021) for soy-melon-okra enriched *gari,* soy-melon enriched *gari* and African yam bean enriched *gari* respectively. The EG that hulls is added to them before fermentation had reduced HCN than those added after fermentation. This simply suggests the effects of fermentation in reduction of HCN.

The titratable acidity of the EG ranged from 0.96 % ($G_{97}CNF_3$: Cowpea hull added after fermentation at ratio 3%: 97% *gari*) to 1.15 % ($G_{95}CF_5$: Cowpea hull added before fermentation at ratio 5%: 95% *gari*). The increase in titratable acidity of the EG may be link to the increase in amino acid content of the samples from the cowpea hulls (Karim et al., 2015). The result is greater than 0.13 to 0.25 % and 0.06 to 0.27 % and 0.41 to 0.47 % Soy-melon-okra-moringa enriched gari, African yam bean enriched gari and soy-melon enriched gari (Karim et al., 2015; Olatunde et al., 2021; Oluwamukomi et al., 2015) respectively.

The result shows that pH ranged from 3.87 to 3.99. The difference in pH value of the samples is very close. However, significant difference ($p<0.05$) exists among the samples. The *gari* sample enriched before fermentation recorded reduced pH values and increased acidity. This implies that the inclusion level and ratio of enrichment of *gari* with cowpea hulls tends to make the EG less acidic

Table 5: Vitamins contents of cowpea hull-enriched *gari.*

Samples	B2	B3	B5	Ascorbic	B-carotene	Vitamin K
			(mg/100g)			
G_{100}	$0.23^{e}\pm0.00$	$0.87^{c}\pm0.00$	$0.02^{e}\pm0.00$	$4.03^{f}\pm0.00$	$0.05^{d}\pm0.01$	$0.11^{e}\pm0.00$
$G_{97}CF_3$	$0.21^{f}\pm0.00$	$1.01^{b}\pm0.00$	$0.03^{de}\pm0.00$	$5.12^{d}\pm0.01$	$0.04^{d}\pm0.00$	$0.13^{d}\pm0.00$
$G_{95}CF_5$	$0.22^{e}\pm0.00$	$1.02^{a}\pm0.00$	$0.03^{cd}\pm0.00$	$6.00^{c}\pm0.02$	$0.46^{b}\pm0.02$	$0.14^{c}\pm0.00$
$G_{93}CF_7$	$0.26^{d}\pm0.01$	$1.02^{a}\pm0.00$	$0.04^{c}\pm0.00$	$7.02^{a}\pm0.02$	$0.05^{d}\pm0.00$	$0.15^{a}\pm0.00$
$G_{97}CNF_3$	$0.27^{c}\pm0.00$	$1.02^{a}\pm0.00$	$0.05^{b}\pm0.00$	$4.91^{e}\pm0.01$	$0.05^{d}\pm0.00$	$0.14^{cd}\pm0.00$
$G_{95}CNF_5$	$0.29^{b}\pm0.00$	$1.02^{a}\pm0.00$	$0.05^{b}\pm0.00$	$5.01^{de}\pm0.01$	$0.60^{a}\pm0.00$	$0.14^{bc}\pm0.00$
$G_{93}CNF_7$	$0.31^{a}\pm0.00$	$1.02^{a}\pm0.00$	$0.06^{a}\pm0.00$	$6.52^{b}\pm0.00$	$0.08^{c}\pm0.00$	$0.14^{ab}\pm0.00$

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

by the dilution effect of the hulls on the sourness of EG (Oluwamukomi & Adeyemi, 2015). This may also be connected to the generation of ammonia from the cowpea hull protein during the degradation of protein (Banjo & Ikenebomeh, 1996). The values obtained were comparable to the range (3.62 to 4.94, 3.58 to 4.94) obtained by Oluwamukomi & Adeyemi, 2015; Oluwamukomi et al., (2007) for soy-melon enriched gari, g*ari* semolina fortified with full fat soy-melon blends respectively but lower than 5.3 to 5.9 and 4.20 to 4.35 reported by Karim et al., (2015) & Olatunde et al., (2021) for African yam bean and soy-melon-okra-moringa enriched *gari* respectively.

Table 6: Hydrogen cyanide, total titratable acidity and pH contents of cowpea hull-enriched *gari.*

Samples	HCN (mg/kg)	TTA (%)	pH
G_{100}	$3.26^{a}\pm0.00$	$1.10^{c}\pm0.00$	$3.89^{cd}\pm0.03$
$G_{97}CF_{3}$	$2.88^{c}\pm0.01$	$1.08^{d}\pm0.00$	$3.91^{bcd}\pm0.01$
$G_{95}CF_{5}$	$2.55^{e}\pm0.00$	$1.15^{a}\pm0.01$	$3.87^{d}\pm0.01$
$G_{93}CF_{7}$	$2.37^{f}\pm0.01$	$1.07^{d}\pm0.01$	$3.96^{ab}\pm0.01$
$G_{97}CNF_{3}$	$3.00^{b}\pm0.01$	$0.96^{e}\pm0.00$	$3.99^{ab}\pm0.00$
$G_{95}CNF_{5}$	$2.66^{d}\pm0.00$	$1.13^{b}\pm0.00$	$3.96^{ab}\pm0.03$
$G_{93}CNF_{7}$	$2.36^{f}\pm0.02$	$1.12^{b}\pm0.01$	$3.93^{bc}\pm0.01$

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

Anti-nutritional properties of cowpea hull-enriched *gari*

The presence of anti-nutritional factors in plants material significantly affects its usage due to it deleterious effect in human body which limits its nutritional value and utilization. Different processing methods have been reported to reduce these anti-nutritional factors to a safe level for consumption by human (Ogunlakin et al., 2015; Rasha et al., (2011); Agte et al., 1999; Ayagari et al., 1980). The trypsin inhibitor, phytate and total phenolic content showed that fermentation significantly ($P<0.05$) reduced anti-nutritional factors (Table 7).

Trypsin inhibitor activity of the EG ranged between 0.00 and 1.86 mg/100g. There was no activity detected in the control sample G_{100} (100% *gari*) due to absence of cowpea hull in the sample while $G_{93}CNF_{7}$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the highest value (1.86 mg/100g). Value obtained is slightly lower compared to (0.00 to 2.11 mg/100g) but slightly higher than (0.00 and 1.350 mg/100g) obtained by Samuel et al., (2012) & Ogunlakin et al., (2015) for soy-enriched tapioca and gari respectively. Significant difference was observed among the sample which was as a result of different inclusion level and fermentation. The trypsin inhibitor activity was high in the EG that has their hulls not fermented with the cassava mash during processing. This confirms the desirable effect of fermentation. Hence, fermentation is a good processing method to reduce trypsin inhibitor activity since trypsin inhibitor has received attention and reported to cause growth retardation, inhibition of digestive enzymes, poor food/feed efficiency and conversion ratio (Owuamanam et al., 2010). The significant reduction in the trypsin inhibition activity of the fermented EG might be attributed to microbial degradation of the trypsin inhibitor that takes place during the fermentation process (Rahman & Osman, 2011). Trypsin inhibitors slow or retard the activity of protein thereby limiting the action of the enzyme trypsin; proteolytic enzyme trypsin that is secreted by the pancreas and thus affects the digestibility and bioavailability of protein (Cristina Oliveira et al., 2019; Sindhu & Khetarpaul, 2001).

Phytates are undesirable in food as they form complexes with nutrients in foods and usually form insoluble salts with mineral elements such as calcium, iron and zinc thereby preventing their metabolism in the body system (Sarkiyayi & Agar 2010). The phytate content ranged from 2.36 to 6.14 mg/100g. Sample $G_{93}CNF_{7}$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the highest value (6.14 mg/100g). The value obtained is very low compared to 208.7 to 263.49 mg/100g obtained from soy-melon enriched *gari* by Oluwamukomi & Adeyemi (2015). The gari samples that have the cowpea hull added before fermentation and fermented with the cassava mash during processing had reduced phytic content. This agrees with the report of several authors that phytate is water soluble and can leached out of samples during soaking, fermentation and draining (Abdou et al., 2020). Bishnoi et al., (1994) and Mazahib et al., (2013) reported that phytic acid content was reduced in beans soaked in water. Abiodun & Adepeju (2011) reported that Bambara nut coat had higher phytate content while dehulling, draining of water and boiling drastically reduces its content. The values obtained in this study were found to be lower than the reported lethal dose of 250 to 500 mg/100g (Bushway et al., 1998). The phytate obtained in this study were favourable since phytates have been reported to form chelate with minerals like calcium, magnesium, iron and zinc thereby rendering them metabolically unavailable, reduction in formation of blood (oxygenated blood) and leading to the development of osteomalacia in some growing animals.

Different phenolic compounds in food have been reported to cause browning reaction due to inherent enzymes in plant food known as phenolic-oxidase. This enzyme reacts with oxygen in the environment to form browning reaction (Singleton et al., 1999). Different authors has reported the activities of various polyphenolic compounds and how their exhibit antioxidant activities because of the reactivity of the phenolic moiety, scavenging free radicals through electron donation or hydrogen donation (Jayaprakasha & Patil, 2007). The mean values of total phenolic content (TPC) equivalent to gallic acid of the EG varied between 32.37 and 43.38 mg GAE/100g. The control sample had significantly ($p<0.05$) lower TPC value (32.37 mg GAE/100g) while $G_{93}CNF_{7}$ (Cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the highest value (43.38 mg GAE/100g). There is no reported value of the total phenolic content of cowpea hull but different authors have reported values for different variety of cowpea which can be used as a basis. Sreeramulu et al. (2013) reported 41.3 to 284.3 mg GAE/100 g for different variety of whole cowpea while value of 46.48 to 269.39 mg GAE/100 g and

38.6 and 542.7 mg/100 g was reported by Adjei-Fremah et al. (2015) and Parikh & Patel (2017)

Hence, the reduction recorded in anti-nutritional factors in the *gari* samples could be of nutritional advantage because this will make nutrients available in the body. Concentrations of anti-nutritional factors were generally higher in EG that have their cowpea hulls not fermented with the cassava mash during processing than their fermented counterparts.

Table 7: Anti-nutritional properties of cowpea hull-enriched *gari.*

Samples	Trypsin Inhibitor (mg/100g)	Phytate (mg/100g)	Total Phenolic Content (mg GAE/100g)
G_{100}	0.00^{g} ±0.00	2.36^{f}±0.01	32.37^{g}±0.03
$G_{97}CF_3$	0.50^{f}±0.01	2.99^{e}±0.01	37.17^{f}±0.00
$G_{95}CF_5$	0.88^{d}±0.00	3.99^{d}±0.07	37.87^{e}±0.07
$G_{93}CF_7$	1.56^{b}±0.02	6.06^{b}±0.01	38.47^{d}±0.02
$G_{97}CNF_3$	0.54^{e}±0.00	3.01^{e}±0.01	40.37^{c}±0.14
$G_{95}CNF_5$	1.01^{c}±0.01	4.15^{c}±0.00	42.16^{b}±0.06
$G_{93}CNF_7$	1.86^{a} ±0.01	6.14^{a}±0.02	43.38^{a}±0.03

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

Sensory properties and acceptability

Sensory properties and acceptability of cowpea hull-enriched *gari*

The sensory property of EGs is presented in Table 8. A panel of sensory analyst was employed to evaluate the organoleptic properties of the enriched *gari* samples. The panel found that in terms of colour, aroma, mouth feel, texture, and overall acceptability; there was significant ($p<0.05$) difference between the blends.

The sensory analysis of the colour showed a ranged of 1.92 to 8.90. The control sample G_{100} (100% *gari*) had the highest score (8.90) while $G_{93}CNF_7$ (cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the lowest score (1.92). This is not far fetch as to why the control sample was score high. This may be because the panelists are consumers of *gari* and they are familiar with the colour of EG that is not enriched and also because the cowpea hulls have masked the colour changing it from creamy colour to light brown and particles of black colour was also found in the EG depending on the quantity added. The colour of the samples changed as level of inclusion is increased. The samples that had their hull fermented with the cassava mash during the production of the EG had high sensory colour score than their unfermented counterpart.

The sensory score for aroma ranged from 1.44 to 7.84. The control sample G_{100} (cowpea hull 0%: 100% *gari*) had the highest score (7.84) followed by sample $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) which score (6.40) while $G_{93}CNF_7$ (cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the lowest score (1.44).

The mouth-feel of the samples which include sourness, coarseness etc. was also determined and the score varies from 1.18 to 8.06. The control sample G_{100} (cowpea hull 0%: 100% *gari*) had the highest score (8.06) while $G_{93}CNF_7$ (cowpea hull added after fermentation at ratio 7%: 93% *gari*) had the lowest score (1.18). The enrichment of the *gari* samples had significant ($p<0.05$) effects on the mouth-feel. The fermented cowpea hull EG had high mouth-feel score i.e. they are sour and finer than their unfermented counterpart that have coarse particles due to the fact that cowpea hulls added to them are not fermented. The high score recorded by sample ($G_{97}CF_3$, $G_{95}CF_5$ and $G_{93}CF_7$) may be due to hydrolysis and soften of the hulls during fermentation then sieving of the mash containing the cowpea hulls also caused a reduced coarseness making the consumers to score the samples high.

Addition of cowpea hulls and fermentation has a marked effect on the textural sensory qualities of the EGs. The control sample score high than the enriched samples. This may be because the control sample did not have any hulls added to it which make it to be more granular and finer than the enriched counterpart. The sensory score for texture ranged from 8.50 for G_{100} (cowpea hull 0%: 100% *gari*) and 1.92 for $G_{93}CNF_7$ (cowpea hull added after fermentation at ratio 7%: 93%).

Consumer acceptability is the most important factor in food product development. The sample $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) had high score (7.58) after the control sample G_{100} (cowpea hull 0%: 100% *gari*) had the highest score (8.54) and $G_{93}CNF_7$ (cowpea hull added after fermentation at ratio 7%: 93% *gari*) had least score (1.52). Fermentation of the cowpea hulls with the mash during production of *gari* enhanced the sensory characteristics and make them acceptable than their unfermented counterpart due to significant ($p<0.05$) change in colour, aroma, mouth-feel to detect the coarseness, sourness etc. and texture.

Sensory properties and acceptability of *eba* made from cowpea hull-enriched *gari*

The result of sensory properties and acceptability of reconstituted *gari* (*eba*) enriched with cowpea hull in Table 9 shows that the mean value of the panelists on colour ranged from 2.20 to 8.60. The control G_{100} (100% *gari*) was ranked the best among the samples. This may be due to the fact that panelists are familiar with the colour characteristics of *eba*. The *eba* from $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) ranked second (6.98). Consumer complained on the significant changes in colour of *eba* made from ($G_{97}CNF_3$: Cowpea hull added after fermentation at ratio 3%: 97% *gari*, $G_{95}CNF_5$: Cowpea hull added after fermentation at ratio 5%: 95% *gari*, $G_{93}CNF_7$: Cowpea hull added after fermentation at ratio 7%: 93% *gari*) which changes the colour of *the eba* to light brown compared to a creamy *eba* characteristics.

The result of aroma showed that $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) ranked next after the control sample which was significantly ($p<0.05$) different from other samples. The cowpea hulls fermented with the cassava mash had high score than their

unfermented counterpart which was significantly different. This is not unconnected with the report of Karim et al., (2015) that fermentation significantly increases the aroma content of food samples due to the activities of enzyme and inherent micro-organism which are present during fermentation.

The control sample was the most preferred for mouth feel which score (8.40) followed by $G_{97}CNF_3$ (Cowpea hull added after fermentation at ratio 3%: 97% *gari*) which score (6.10). The values obtained was significantly ($p<0.05$) different from each other. Increased inclusion of the cowpea hulls causes reduction in the mouth-feel quality as seen in the score recorded by the panelists.

On the texture property, $G_{93}CNF_7$ (cowpea hull added after fermentation at ratio 7%: 93% *gari*) had least score (3.20) which is significantly ($p<0.05$) different from all other samples while G_{100} (100% *gari*) had the highest score (8.18) followed by $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*). The trend in the score for texture of the samples is true when compared with the result of the moisture content of the samples as reported in Table 2.

The mouldability score followed the same trend. Sample $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) and $G_{97}CNF_3$ (Cowpea hull added after fermentation at ratio 3%: 97%) was rated next (6.20) to the control sample (8.20). There was significant ($p<0.05$) difference between the samples. The result shows that 3% inclusion is the best to have a good mouldability value. In overall acceptability the control G_{100} (100% *gari*) sample had the highest score (8.40) followed by $G_{97}CF_3$ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) which score (6.30) and $G_{97}CNF_3$ (Cowpea hull added after fermentation at ratio 3%: 97%) with score of (6.20). This shows that fermentation of the cowpea hull with cassava mash and 3% inclusion is the best according to consumer preference.

CONCLUSION

Gari was enriched with cowpea hull. The enrichment and inclusion level significantly affected the physicochemical and sensory properties of *gari*. The fermented cowpea hull with the cassava mash showed better nutritional, anti-nutritional and sensory properties than their unfermented counterpart. Enrichment of *gari* using 7 % cowpea hull had the best crude protein, crude fibre, calcium, sodium, ascorbic acid and vitamin K contents. Hence, instead of discarding cowpea hull after processing and production of traditional and commercial food, enriching *gari* with this bye-product may reduce the incidence of food insecurity in area where *gari* is consumed. Results obtained in this study will be useful in the preparation of cowpea hull-enriched *gari*. The commercial production of enriched *gari* with cowpea hull and inclusion of 7 % cowpea hull into the cassava mash before fermentation is recommended. However, further research is needed to determine quality parameters in real-life scenarios, explore inclusion levels up to 10%, and investigate the effects of extended storage. Overall, this study provides valuable insights into the potential benefits of enriching *gari* with cowpea hulls, not only in terms of improving its nutritional content but also in contributing to food security in regions where *gari* is a staple food.

Table 8: Sensory properties and acceptability of cowpea hull-enriched *gari.*

Sample	Colour	Aroma	Mouth-feel	Texture	Overall acceptability
G_{100}	$8.90^{a}\pm0.30$	$7.84^{a}\pm0.47$	$8.06^{a}\pm0.84$	$8.50^{a}\pm0.51$	$8.54^{a}\pm0.50$
$G_{97}CF_3$	$7.24^{b}\pm0.63$	$6.40^{b}\pm0.78$	$7.58^{b}\pm0.50$	$7.58^{b}\pm0.50$	$7.58^{b}\pm0.50$
$G_{95}CF_5$	$5.00^{d}\pm0.00$	$4.88^{c}\pm0.33$	$4.92^{c}\pm0.27$	$6.12^{c}\pm1.12$	$4.98^{c}\pm0.14$
$G_{93}CF_7$	$4.60^{e}\pm0.81$	$4.80^{c}\pm0.93$	$5.04^{c}\pm1.28$	$5.00^{e}\pm0.64$	$3.60^{d}\pm0.50$
$G_{97}CNF_3$	$5.30^{c}\pm0.76$	$4.60^{c}\pm0.50$	$4.76^{c}\pm0.66$	$5.34^{d}\pm0.87$	$5.14^{c}\pm0.83$
$G_{95}CNF_5$	$3.52^{f}\pm0.71$	$3.20^{d}\pm1.18$	$3.48^{d}\pm1.59$	$3.74^{f}\pm0.97$	$3.20^{e}\pm0.40$
$G_{93}CNF_7$	$1.92^{g}\pm0.27$	$1.44^{e}\pm0.50$	$1.18^{e}\pm0.63$	$1.92^{g}\pm0.60$	$1.52^{f}\pm0.51$

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

Table 9: Sensory properties of *eba* made from cowpea hull-enriched *gari.*

Sample	Colour	Aroma	Mouth-feel	Texture	Mouldability	Overall acceptability
G_{100}	$8.60^{a}\pm0.50$	$7.80^{a}\pm0.99$	$8.40^{a}\pm0.50$	$8.18^{a}\pm0.75$	$8.20^{a}\pm0.76$	$8.40^{a}\pm0.50$
$G_{97}CF_3$	$6.98^{b}\pm0.89$	$7.16^{b}\pm0.89$	$5.80^{b}\pm2.06$	$6.42^{b}\pm1.54$	$6.20^{b}\pm1.18$	$6.30^{b}\pm1.40$
$G_{95}CF_5$	$4.60^{d}\pm0.81$	$5.20^{d}\pm1.18$	$4.60^{c}\pm1.51$	$4.20^{c}\pm0.76$	$3.64^{d}\pm0.75$	$4.20^{c}\pm0.76$
$G_{93}CF_7$	$3.80^{e}\pm1.49$	$5.00^{d}\pm1.43$	$4.40^{c}\pm1.21$	$4.58^{c}\pm1.40$	$4.00^{cd}\pm1.28$	$4.20^{c}\pm1.18$
$G_{97}CNF_3$	$6.56^{c}\pm0.89$	$6.40^{c}\pm1.21$	$6.10^{b}\pm1.25$	$6.20^{b}\pm0.40$	$6.20^{b}\pm1.18$	$6.20^{b}\pm0.76$
$G_{95}CNF_5$	$4.00^{e}\pm0.64$	$5.00^{d}\pm1.11$	$4.60^{c}\pm0.81$	$4.20^{c}\pm0.40$	$4.20^{c}\pm1.18$	$4.40^{c}\pm0.81$
$G_{93}CNF_7$	$2.20^{f}\pm0.99$	$3.60^{e}\pm2.60$	$3.00^{d}\pm0.90$	$3.20^{d}\pm0.76$	$2.40^{e}\pm0.81$	$2.60^{d}\pm0.81$

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

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DECLARATION OF CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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