Rheology and Acceptance of Pap (*Zea mays*) Enriched with *Jatropha carcus* Leaves to Improve Iron Status in Children

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This work was carried out in collaboration between both authors. Author NNU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AIA managed the analyses of the study. Author NNU managed the literature searches. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

This study was carried out to determine the Rheology and acceptance of Pap (*Zea mays*) enriched with *Jatropha carcus* leaves to improve iron status in Children. The blends of pap slurry and *Jatropha curcas* leaves was made at substitution level of 70:30 respectively. However, the sample formulation was coded as sample A for 100% pap, B for 100% *Jatropha curcas* leaves and sample C for 70% pap and 30% *Jatropha curcas* leaves. Sensory evaluation was conducted on the gruel made from the samples to test acceptability. All samples were subjected to laboratory analysis for proximate, mineral, anti-nutrients, viscosity and functional properties using standard method and thereafter, the results obtained were further subjected to statistical analysis using SPSS. The result showed that the proximate composition of the samples ranged from 11.82 to 43.31% for moisture, fibre 2.71 to 10.20%, protein 3.24 to 6.28%, carbohydrate 41.61 to 61.55% and energy 250.10 to 401.50 kcal. The minerals were also ranged from 4.62 to 10.04 mg/100 g for iron, magnesium 62.55 to 112.01 mg/100 g, zinc 0.03 to 0.67 mg/100 g and calcium 44.21 to 110.28 mg/100 g. The anti-nutrients were found to be tannin 0.03 to 2.67 mg/100 g, phytate 0.34 to 1.11 mg/100 g, oxalate

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0.91 to 2.64 mg/100 g, and saponin 0.00 to 1.24 mg/100 g. The study however showed that the functional properties of 100% pap and the pap fortified with *Jatropha carcus* leaves were water absorption capacity 65.78 and 52.68%, oil absorption capacity 140.20 and 120.00%, and foaming capacity 22.45 and 28.01% respectively. The panelist preferred the 100% pap than the pap enriched with *Jatropha curcas* leaves. This study has revealed an increase in iron, magnesium and zinc which shows that fortification of pap with *Jatropha curcas* leaves will enhance the iron status of the populace.

1. INTRODUCTION

Iron deficiency anemia (IDA) in young children is recognized as a major public health issue and one detrimental form of micronutrient deficiency worldwide [1]. IDA contributes substantially to childhood mortality and morbidity and is linked to impaired brain development and cognitive functions [1]. Children, particularly young ones, are more susceptible to anemia and iron deficiency (IDA) because of high iron requirements during growth, low intake of iron from complementary foods, and frequent episodes of infection [2]. Breast milk contains relatively low levels of iron but it is readily absorbable and sufficient for infants up to six months of age.

A traditional Nigerian diet and Nigerian complementary foods are usually (pap) cereal based which contain very few nutrients [3]. There is low iron content in pap due to the fact that cereals are not good sources of iron [4]. In the last national survey of 2011 among children less than 12 months, only about 13% were reported having consumed iron-rich foods [4]. Pap is a fermented semi-solid food product manufactured from cereals (commonly maize, sorghum or millet). It is a staple food in most African countries, with varying preparation methods and names. It is commonly used as complementary/ weaning food for babies and also for young children and as a standard breakfast cereals in many homes [5].

Enrichment and fortification may be commercial choice to provide extra nutrients in a food, or a public health policy that aimed at reducing dietary deficiencies within a population [6].

Physic nut *(Jatropha curcas)* has been known in some native Igbo land as 'Ahihia Ogwu Obara' and recent study and research has proven that the leaves has high level of iron and magnesium [7]. Extracts from *Jatropha curcas* possess moluscicidal, piscicidal, insecticidal, rodenticidal, antimicrobial, and cytotoxic properties, and exert adverse effects on animals including rats, poultry, and ruminants [7]. In contrast, Ngwa [8] observed no adverse effect on albino rats rather it improves the iron status in rats. Therefore this study was aimed at enriching pap with *Jatropha carcus* leaves to improve iron status in children.

2. MATERIALS AND METHODS

2.1 Procurement of Samples

Maize grains were bought from Ogbete Main Market, Enugu while *Jatropha curcas* leaves were obtained from a farm in Owerri North Local Government Area, Imo State both in Nigeria.

2.2 Processing of Samples

Pap was prepared using a method described by Abioye and Aka [9] with slight modifications. Maize was thoroughly cleaned by picking out all broken kernels together with other foreign particles and then sorted to obtain the wholesome ones. Then 1 kg of maize kernels were washed, soaked in 10 L of water and allowed to stand for 72 hours at ambient temperature. The steep water was changed each day for the three days. After the third day, the steep water was discarded and the grains wet milled using a grinding machine/grinder. The milled slurry was then wet sieved using a muslin cloth to remove bran, hull and germ. The pomace was then retained on the sieve and discarded while the Pap slurry was collected in a muslin cloth and hand squeezed to remove excess water leaving behind a semi solid Pap which was stored in the freezer for further analysis.

2.3 Processing of *Jatropha curcas* Leaves

This was processed using the method as described by George et al. [10]. The whole fresh leaves of *Jatropha curcas* was harvested, sorted, washed, oven dried at 300°C for half an hours, ground to powdery form, sieved with 75 mm mesh aperture size and packaged in plastic container until it was needed for further use.

2.4 Preparation of *Jatropha curcas* Leaf /Pap Blends

The blend was prepared using the method of Abioye and Aka [9]. Pap slurry was supplemented with *Jatropha curcas* leaves at substitution level of 70:30 and then mixed thoroughly to obtain homogenous *Jatropha curcas*-Pap blends.

2.5 Coding of Sample

Table 1. Sample coding

Sample	pap%	*Jatropha curcas* %
A	100	0
B	0	100
C	70	30

A=100% pap, B= 100% Jatropha curcas and C= 70:30 pap-Jatropha

2.6 Proximate Analysis

Moisture determination: The moisture content of the samples was determined using the air oven method of AOAC [11].

Protein determination: Crude protein content of the samples was determined using the automated micro-Kjeldahl method as described by AOAC [11].

Fat determination: The fat content was determined using the Soxhlet extraction method [11].

Crude fibre determination: The crude fibre content of the samples was determined according to the procedure of AOAC [11].

Ash determination: The ash content was determined according to the procedure of AOAC [11].

Carbohydrate determination: Carbohydrate content was calculated by difference. The estimated percentages of crude protein, ash, fat, fibre and moisture was summed up and the value subtracted from 100%.

CHO = 100% - % (protein + fat + ash + fibre +moisture).

Mineral determination: The mineral contents, namely: Na, K, Ca, Mg, Cu, Mn, Hg and Pb contents were determined by the method described by Pearson [12] using a Pye Unicam SP9 Atomic Absorption Spectrophotometer (AAS) connected to an SP9 computer (Pye Unicam Ltd, York Street, Britain). Total phosphorus was determined by the spectrophotometric molybdovanadate [11].

Phytochemical screening: A small portion of the extract was subjected to the phytochemical test using Trease and Evans [13] and Harbourne [14] methods to test for alkaloids, flavonoids, saponins, lycopene, phenol and cardiac glycoside. The Folin-Denis Spectrophotometer method was used to determine the tannin content of the foods. The method was described by Pearson [12]. Cyanide was determined by Wang and Filled method [15]. Phytate was determined from duplicate samples of food using diluted HCL [16]. Oxalate determination was carried out as described by Suree et al. [17].

2.7 Functional Properties

Water absorption Capacity (WAC): Approximately 2 g sample was dispersed in 20 ml of distilled water. The contents were mixed for 30s every 10 min using a glass rod and after mixing five times, centrifuged at 4000 g for 20 min. The supernatant was carefully decanted and then the contents of the tube were allowed to drain at a 45° angle for 10 min and then weighed. The water absorption capacity was expressed as percentage increase of the sample weight [18].

Oil Absorption Capacity (OAC): Oil absorption capacity of the flour samples was determined by the centrifugal method with slight modifications. One gram of sample was mixed with 10 ml of pure canola oil for 60 s, the mixture was allowed to stand for 10 min at room temperature, centrifuged at 4000 g for 30 min and the oil that separated was carefully decanted and the tubes were allowed to drain at a 45° angle for 10 min and then weighed. Oil absorption was expressed as percentage increase of the sample weight [19].

Bulk density: The bulk density was determined according to the method described by Udoro et al. [20]. A 20 g sample was put into 50 ml measuring cylinder. The cylinder was gently tapped on the bench top 10 times from a height of 5 cm. The bulk density was calculated as weight per unit volume of sample.

Calculation:

Bulk Density (BD) g/ml = $(Weight\ of\ Sample)/Volume\ of\ sample\ after\ tapping$

Jatropha curcas leaves

Fig. 1. Prepared Pap for Infant Food Formulation

Swelling Properties: The method used was as described by Okaka and Potter [21]. About 25 g of flour was measured into a 100 ml measuring cylinder. The measuring cylinder was then filled with water to 100 ml bench mark. The mixture was shaken several times and allowed to settle. The volume of the flour was recorded after 15 minutes. The percentage swelling in the volume was determined by the difference in volume divided by the initial volume. Thus % swelling property =

$$(C – D)/A$$

Where

- A = Initial volume (equivalent volume of the 25 g flour sample)
- B = Volume before swelling
- C = Volume after swelling

Foam Capacity (FC): The procedure of Narayana and Narsinga Rao [22] was used. Two grams of flour sample and 50 ml distilled water were mixed in a Braun blender at room temperature. The suspension was mixed and shaken for 5 minutes at 1600 rpm. The content along with the foam was poured into a 100 ml graduated measuring cylinder. The total volume was recorded after 30 seconds. Then the content was allowed to stand at room temperature for 30 minutes and the volume of foam only was recorded.

Foaming Capacity (FC) = (Vol. of foam AW − Vol. of foam BW)/ Vol. of foam AW x 100

Where:

- AW = After Whipping
- BW = Before Whipping
- FS: The volume of foam only (Total volume – liquid volume) after the 30 min standing is taken as foam stability.

Viscosity: Viscosity (AV) The apparent viscosity of slurries were determined by the methods of Beuchat [23] and was determined by placing Twenty grams of the sample in measuring cylinder of 100 ml of water in an oiling water bath of 75 – 80°C. The slurry was constantly stirred and until boiling which was continued for five minutes. The slurry was cooled to room temperature 23 – 25°C and their viscosity were measured with a cannon viscometer.

Sensory Analysis: Twenty (20) semi trained panelist consisting of nursing mothers, staff and students of the Department of Food Science and Technology, Enugu State University of Science

and Technology, Enugu were constituted and used for the study. The sensory parameters were rated on the basis of 9- point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The gruel were prepared from both the control and the enriched complementary food samples. Fifty grammes (50 g) of each sample of complementary food were mixed with 150 mL of cold water to make slurry. Thereafter, 100 mL of boiling water was added to the slurry in each case with continuous stirring to obtain homogenous porridges. Two grammes (2 g) of granulated sugar were added to each sample of the porridge. The porridges were evaluated for the attributes of colour, taste, mouthfeel, texture and overall acceptability. Prior to the sensory test, the gruel were individually coded and served to the panelists in white plastic cups with teaspoons at ambient temperature. Clean water was provided to the judges to rinse their month in-between testing of the gruel to avoid residual effect [24]. Expectoration cups with lids were provided for the panelists who were not interested to swallow the samples.

2.8 Anti-Nutrient Determination

Phytate determination: Phytate was determined using the method of AOAC [11].The sample (0.5 g) was extracted with 100 ml of 2.4% HCl for 1 h at room temperature. The extract (5 ml) was pipette into a test tube and diluted with 25 ml of distilled water. 0.7 M sodium chloride (15 ml) was added and the absorbance was read at 520 nm using UV/Vis spectrophotometer. The value was calculated from a prepared standard curve and blank.

Oxalate determination: Oxalate was determined using the method of AOAC [11]. One gram of the powdered sample was weighed and put into a test tube and 47.5 ml of water and 2.5 ml of 6 N hydrogen chloride were added to the powdered sample. It was boiled for 1 h and made up to 62.5 ml with water. The solution was cooled at room temperature and filtered. Some filtrate (12.5 ml) was taken and the pH was adjusted to the range of 4.0 to 4.5 with dilute ammonia (NH3). The solution was heated up to 90°C, filtered and heated up again to 90°C. Then, 5 ml of calcium chloride was added to the solution with constant stirring. The solution was allowed to stand overnight. The solution was centrifuged for 5 min and the supernatants were decanted off. The precipitate was dissolved with 5 ml of 20% sulphuric acid. It was heated until about to boil. The solution was then titrated with 0.5 N standards. KMNO4 until a pale pink color that persisted for 30 s was attained and the percentage oxalate was calculated.

Saponin determination: The method used was also as described by AOAC, [11]. Twenty grams of the powdered sample was placed in 200 ml of 20% ethanol. The suspension was heated over water bath for 4 h with continuous stirring at 55°C. The mixture was filtered and the residue re-extracted with 200 ml of 20% ethanol. The combined extracts were reduced to 40 ml over water bath at 90°C. The concentrate was transferred into a 250 ml separator funnel and 20 ml diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. Then 60 ml of n-butanol extracts were washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation, the sample was dried in the oven to a constant weight. The Saponin content was calculated in percentage.

Determination of Tannin: Tannin content of the sample was determined Folin Denis Colometric method according to AOAC [11]. A measured weight of the processed sample (5.0 g) was mixed with distilled water in the ration of 1:10 (w/v). The mixture was shaken for 30 minutes at room temperature fittered to obtain the extract. A standard tannic acid solution was prepared, 2ml of the standard solution and equal volume of distilled water were dispersed into a separate 50 ml volumetric flask to serve as standard and reagent blank respectively. Then 2 mls of each of the sample extract was put in their respective lapelled flask. The content of each flask was mixed with 35 ml distilled water and 1ml of the Folin Denis reagent was added to each. This was followed by 2.5 mls of saturated Na2 CO3 solution. There after each flask was diluted to the 50 ml mark with distilled water and incubated for 90 minutes at room temperature. Their absorbance was measured at 760 nm in a spectrophotometer with the reagent blank at zero.

The tannin content was calculated as show below:

$$\% \text{ tannin} = \frac{100}{W} \quad x \quad \frac{Au}{As} \quad x \quad \frac{C \times Vt}{Va}$$

W = weight of sample
Au= absorbance of test sample
As = absorbance of test sample
C = concentration of standard tannin solution

Vt = total volume of extract
Va = volume of extract analyzed

Determination of Hydrogen Cyanide (HCN): This was determined by alkaline Pikrate colorimeter method by AOAC [11]. About 1.02 g of this sample was dispersed in 50 ml of distilled water in a 25.0 ml conical flask. An alkaline Pikrate paper was hung over the sample mixture and the blank in their respective flasks. The set up were incubated overnight and each Pikrate paper was eluted (or dipped) into a 60ml of distilled water. A standard cyanide solution was prepared and diluted to a required concentration. The absorbance of the diluted sample solution of the standard was measured spectophoto-metrically at 540 nm wavelength with the reagent blank at zero. The cyanide content was determined by the formular shown below:

HCN mg/kg =   (1000 x Au x CxD)/W

Where

W = weight of sample analyzed
Au= absorbance of test sample
As = absorbance of standard HCN solution
C = concentration of the standard in mg/dl
d = dilution factor where applicable.

Glycosides: The method of AOAC [11] was used. One gram of the sample was mixed with 20 ml of water. Some quantity (2.5 ml) of 15% lead acetate was added to the filtration and the solution was shaken vigorously. It was allowed to settle and the lower layer was collected and evaporated to dryness. The residue was dissolved with 3 ml of glacial acetic acid. About 0.1 ml of 5% ferric chloride was added. Some 0.25 ml of conc H_2SO_4 was also added. The solution was vigorously shaken and put in a dark container for 2 h. The absorbance was read at 530 nm.

2.9 Statistical Analysis

All the analysis reported in this study was performed in triplicates and data obtained reported as mean ± standard deviation. One-way ANOVA was used to determine the statistical significance of the results. Duncan new multiple range test was applied to separate the mean [25].

3. RESULTS AND DISCUSSION

Proximate composition: The result of the proximate composition of the sample are shown in Table 2. The moisture contents of the samples were 36.24% pap, 11.82% *Jatropha curcas* leaves and 43.31% Pap/ *Jatropha curcas* leaves. Moisture content is an index of water activity of many foods. These values were lower than moisture content (82%) in pap as recorded by Roger et al. [26]. The variation in moisture could be due to the processing method applied and the quantity of water retained by the pap during analysis. Crude fibre contents of the sample ranged from 2.71% for Pap to 10.20% for *Jatropha curcas* leaves. The crude fibre contents were similar to the findings of Edet et al. [27] that reported 2.10% on maize pap. There is a significant difference among all the samples. The crude fibre contents of the samples were of interest since the FAO recommended fibre content in complementary food is 5 g/100 g [26]. Also the increase in fibre was due to the addition of *Jatropha curcas* leaves. Fibre in food helps in burning of fat and busting of the immune system. It could also provide bulk in the diet, enhance gastrointestinal function, prevent constipation and may reduce the incidence of metabolic diseases like maturity-onset diabetes mellitus and hypercholesterolemia [28]. Protein contents of the samples varied from 3.24% for *Jatropha curcas* leaves to 6.28% for Pap. The protein contents of these samples were similar to the findings of Roger et al. [26] that observed a protein content of 8.9% in maize pap. Cereals are not a good source of protein. Protein is used to build and repair tissue, make enzymes, hormones, and other body chemicals. It is an important building block of bones, muscles, cartilage, skin and blood. Ash contents of the samples ranged from 2.28 to 9.23%. The lowest ash content was obtained from sample A (pap) while the highest was obtained from sample B (*Jatropha curcas* leaves). The ash content of a food is a determinant of the mineral content of that particular food. The ash contents of the samples studied were higher than those of 2.12% reported by Farinde [29] in fortified pap. The fat contents of the samples ranged from 2.26% in sample C (Pap/ *Jatropha curcas* leaves) to 3.96% in sample B (*Jatropha curcas* leaves). There were no significant difference (P>0.05) between sample A and B but differed significantly (P<0.05) from samples C. The lipid contents of the pap samples studied were in line with 4.07% reported by Roger et al. [26] on maize pap. The low fat content in these samples is imperative since it will not predispose one to the risk of heart disease and high cholesterol levels (among other health benefits) when consumed [29]. The low fat content of these

foods will be of interest in the dietary management of obesity, diabetes, cardiovascular diseases and high blood pressure, which are associated with a high intake of fatty foods. Carbohydrate contents of pap ranged between 41.61% for sample C (Pap/ *Jatropha curcas* leaves) to 61.55% for sample B (*Jatropha curcas* leaves). The carbohydrate content in the samples were significantly different (P<0.05) among each other. The carbohydrate contents of the samples in this study were slightly lower than carbohydrate content of 68.04% in pap reported by Ikya et al. [30]. Carbohydrates provide the body with energy and also help in the sparing of protein. The energy values ranged from 250.10 kcal to 401.50 kcal. The higher energy in pap was due to the complex starch which were hydrolyzed during fermentation process. Energy is necessary in the body for all activities. However, the energy values differed significantly (P<0.05) among all the samples.

Mineral: The mineral composition is presented in Table 3. The iron content of the samples ranged from 4.62 mg/100 g to 10.04 mg/100 g. Sample A (pap) had the least iron content while sample B (*Jatropha curcas* leaves) contained the highest iron content. All samples differed significantly (P<0.05) from each other. The iron content in this research agreed with the report of Abioye [31] that reported iron value of fortified maize pap leaves to be 8.37 mg/100 g. Iron is involved in strengthening the immune system. High iron content of pap fortified with *Jatropha curcas* leaves could contribute in preventing anaemia. Iron is the functional component of haemoglobin and other key compounds used in respiration, immune function and cognitive development. The Fe content in pap fortified with *Jatropha curcas* leaves (100 g) could be enough to cover the daily minimum needs (providing about 67 – 68%) for children. [32]. The magnesium content of the samples ranged from 62.55 to 112.01 mg/100 g. Sample B (*Jatropha curcas* leaves) had highest magnesium content while sample A (pap) contained the lowest mean value. The value obtained in this research was similar to the findings of Abioye [31] on fortified maize pap fortified which is 80%. Magnesium provides bone strength, aids enzyme, nerve and heart functions. The zinc content of the samples ranged from 0.03 to 0.63 mg/100 g. Sample C had the highest mean value while sample B had the lowest value; however, all samples differed significantly (P<0.05) from each other. The value obtained in this research corresponded with the findings of Abioye and Aka [9] that recorded the

zinc value of 0.63 mg/100 g on fortified maize pap. Zinc helps with hormone production, growth and repairment; improves immunity and facilitates digestion [33]. Zinc benefits also include its ability to act as an anti-inflammatory agent, therefore zinc may have significant therapeutic benefits for several common, chronic diseases like fighting cancer or reversing heart disease [33]. Zinc is actually present within all bodily tissue and needed for healthy cell division [33]. Zinc also has a big impact on hormonal balance, so for this reason, zinc deficiency can result to an increased risk for infertility or diabetes [33]. Zinc for the treatment of diarrhoea has been recommended by the World Health Organization (WHO) and United Nations Children's Fund (UNICEF). Zinc is an effective therapy for diarrhoea and will decrease diarrhoea morbidity and mortality [34]. The result revealed that the calcium content of the samples ranged from 44.21to 110.28 mg/100 g with sample B having the highest calcium content while sample C had the least quantity. The samples differed significantly (p<0.05) from each other. The values obtained in this research were lower than the result of 152.32 mg/100 g as reported by Farinde [29] on maize pap fortified with soy bean. Calcium had been reported to play a major role in muscle contraction, building strong bones and teeth, blood clotting, nerve impulse, trans-mission, regulating heart beat and fluid balance within cells [35]. It has also been identify to play major role in managing blood pressure and preventing breast cancer [35]. The phosphorus content of the samples ranged from 66.20 t0 198.20 mg/100 g. There was significant different (P<0.05) among all samples. There was decrease in the mean values with substitution of *Jatropha curcas* leaves, thus; sample A (pap) had the highest mean value (198.20 mg/100 g) while sample C (Pap/ *Jatropha curcas* leaves) was lowest with the mean value of 66.20 mg/100 g. Phosphorus enhances quick release of energy in the body and may combine with calcium for bone and teeth development [33]. The potassium content of the samples ranged from 10.16 to 210.00 mg/100 g. Potassium has been reported to play vital role in maintaining fluid balance and proper functioning of the essential organs such as the brain, nerves, heart and muscle [35]. Potassium aids nerve impulse transmission and it is a major cat ion of intracellular fluid. High potassium to low sodium ration in food may be imperative in diet formulations for patients with high blood pressure and oedema as well [33]. There was a decrease in potassium content as the values reduced from 210.00 mg/100 g which

was obtained in sample A (pap) to 162.45 mg/100 g obtained in sample C (Pap/*Jatropha curcas* leaves). There were significant different among all samples, although these values were similar to Abioye [31] with the value of 173.33 mg/100 g in fortified maize pap.

Functional properties: The functional properties of pap and pap/ *Jatropha curcas* leaves were presented in table 4. The result showed that the water absorption capacity ranged from 52.68 to 65.78%. Water absorption capacity of the samples was higher in sample A (pap) with the value of 65.78% than sample B (pap/ *Jatropha curcas* leaves) with the value of 52.68%. The decrease in WAC was due to addition of *Jatropha curcas* leaves powder to the pap. These values obtained were similar to the findings of Oluseyi et al. [36] that had 66.13% in sorghum pap fortified with crayfish. Water absorption capacity represent the ability of a

product to associate with water under conditions where water is limited [37]. The high WAC of pap could be attributed to the presence of higher amount of carbohydrates (starch) in the product [37]. The oil absorption capacity ranged from 120.00 to 140.20%. The result shows that pap had an OAC of 140.20% while pap/*Jatropha curcas* had 120.00%. The higher value of oil absorption capacity was observed for pap (sample A) with the value of 140.20% while the pap blended with *Jatropha curcas* leaves (sample B) had 120.00%. There was similar value of OAC between the values in this study with that of the research work of 135.68% by Odunlade et al. [38] in sorghum pap flour enriched with cocoa. The water and oil binding capacity of food protein depend upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity. Pap having highest OAC could be better to flour blend as flavor retainer. The

Table 2. Proximate composition and energy content of pap, *Jatropha curcas* and pap-*Jatropha curcas* (70:30)

	Moisture %	Fat %	Fibre %	Protein %	Ash %	CHO %	Energy Kcal
A	36.24[a]	3.97[a]	2.71[c]	6.28[a]	2.28[c]	48.52[c]	254.93[c]
B	11.82[c]	0.85[c]	10.20[a]	3.24[c]	3.45[a]	70.44[a]	304.57[a]
C	20.43[b]	2.01[b]	4.10[b]	5.10[b]	2.99[b]	65.37[b]	299.89[b]

Values are mean of 3 replications. Means with different superscript along the same column are significantly different at p<0.05.A=100% pap, 100% Jatropha curcas and 70:30 pap-Jatropha

Table 3. Mineral composition of the sample (mg/100 g)

Sample	Fe	Mg	Zn	Ca	P	K	Na
A	4.62[c]	62.55[c]	0.03[c]	62.00[b]	198.70[a]	210.00[a]	9.97[a]
B	10.04[a]	112.01[a]	0.28[a]	110.28[a]	120.40[b]	10.16[c]	0.24[c]
C	7.66[b]	90.20[b]	0.13[b]	44.21[c]	66.20[c]	162.45[b]	5.60[b]

Values are mean of 3 replications. Means with different superscript along the same column are significantly different at p<0.05.A=100% pap, 100% Jatropha curcas and 70:30 pap-Jatropha

Table 4. Functional properties of the samples

Sample	WAC %	OAC%	Bulk density %	Swelling Index %	Foaming capacity %	Viscocity cps) (25% Conc)
A	65.78	140.20	0.98	22.00	28.01	613.50
B	-	-	-	-	-	-
C	52.68	120.00	1.24	26.13	22.45	625.20

Values are mean of 3 replications. Means with different superscript along the same column are significantly different at p<0.05.A=100% pap, 100% Jatropha curcas and 70:30 pap-Jatropha

Table 5. Antinutrient content of the samples mg/100 g

Sample	Tannins	Phytate	Oxalate	HCN	Glycoside	Saponin
A	0.03[c]	0.38[b]	0.98[b]	0.0[c]	0.0[c]	0.0[c]
B	2.67[a]	1.11[a]	2.64[a]	3.03[a]	2.01[a]	1.24[a]
C	0.18[b]	0.34[b]	0.91[b]	0.45[b]	1.65[b]	0.28[b]

Values are mean of 3 replications. Means with different superscript along the same column are significantly different at p<0.05.A=100% pap, 100% Jatropha curcas and 70:30 pap-Jatropha

Table 6. Sensory properties of the gruel made from the samples

Sample	Colour	Taste	Mouthfeel	Texture	Over all acceptability
A	7.93	7.80	7.87	7.73	7.44
B	5.34	5.40	5.06	5.12	5.10
P-value	.413	.492	.322	.234	.210
T-test	(n=20)	(n=20)	(n=20)	(n=20)	(n=20)

A=100% Maize gruel. B=70:30% maize: Jatropha curcas gruel

ability of the proteins of these flours to bind with oil makes it useful in food system where optimum oil absorption is desired [39]. This makes flour to have potential functional uses in foods such as sausage production. The OAC also makes the flour suitable in facilitating enhancement in flavor and mouth feel when used in food preparation [38]. The bulk density ranged from 0.98 to 1.24%. The result showed that the bulk density of the pap blended with *Jatropha curcas* leaves (sample B) had higher mean value (1.24%) than the pap alone (sample A) with the value of 0.98%. The values obtained were slightly higher than the result of Oluseyi et al. [36] that reported 0.73 g/ml in sorghum pap fortified with Crayfish. The present study revealed that bulk density depends on the particle size and initial moisture content of flours. High bulk density of flour suggests their suitability for use in food preparations. In contrast, low bulk density would be an advantage in the formulation of complementary foods [38]. The value of swelling capacity were 22.00 and 26.13%. The swelling value was found higher for sample B (pap/*Jatropha curcas* leaves flour) with the value of 26.13% than sample A (pap) with the mean value of 22.00%. The swelling capacity of flours depends on size of particles, variety and types of processing methods or unit operations. The values obtained in this study were similar to the findings of Abioye [31] that had 24% in fortified maize pap. The value obtained in foaming capacity were 22.45 and 28.01%. The higher foam capacity was observed in sample A (28.01%) than sample B (22.45). Pap flour had the higher foam capacity due to higher protein content. Protein in the dispersion may cause a lowering of the surface tension at the water air interface, thus making the protein to form a continuous cohesive film around the air bubbles in the foam [40].

The results of the viscosity at 25% concentration were 613.50 and 625.20 cps for A and B respectively. Fortification with *Jatropha curca* recorded a significant P<0.05) increase in viscosity from 613.50 t0 625.20cps. The viscosity

level for this study is in agreement with previous studies [41]. They observed that fermentation decreases the total amount of carbohydrates and other nutrients, since microbial activity requires energy and nutrients.

Sensory properties of the gruel: The sensory properties of the gruel samples were presented in Table 5. The sensory scores for the gruels prepared from the pap and pap/*Jatropha curca* showed significant (p<0.05) difference in colour, taste, texture and general acceptability. The pap gruel scored higher compared to the pap enriched with *Jatropha curcas* in all the parameters evaluated by the judges. The mean score for the enriched sample is 5 which means neither like nor dislike. The lack of acceptance of the enriched sample could be as a result of the fact that people preferred familiar food than unfamiliar food. There is need for Nutrition Education to educate the populace on the nutrient and health benefit of enrichment.

Anti-nutrient: Tannin: The anti-nutrient content of the sample were presented in Table 6. The result of the tannin ranged from 0.03 to 2.67 mg/100 g. Sample B (*Jatropha curcas* leaves) had the highest tannin mean value while sample A (pap) had the lowest tannin content. However, all samples differed significantly (P<0.05) from each other. The tannin content of the sample in this study was similar to the findings of Abioye [31] that reported a mean value of 0.09 mg/100 g in fortified maize pap. The lower content of tannin in sample A could be attributed to fermentation. Food processing like fermentation, sprouting, decanting etc reduces the anti-nutrient content of food thereby activating the hydrolytic enzyme (α and β amalyses) and proteolytic enzyme. According to Allonso et al. [42] decanting of pap greatly reduces condensed tannin and polyphenol. The phytate content of the sample ranged from 0.34 to 1.11 mg/100 g. Phytate content of the samples were highest in sample B (*Jatropha curcas* leaves) with the value of 1.11 mg/100 g while sample C (Pap/*Jatropha curcas*

leaves) had the lowest mean value (0.34). All samples differed significantly (P<0.05) from each other, however, these values agreed with 0.76 mg/100 g reported by Abioye [31] in maize pap fortified with vegetables. The low level of phytic acid would ensure availability of divalent cation. This result indicates that consumption of *Jatropha* leaves will not inhibit/chelate the absorption of minerals especially Ca and Zn [43]. Phytates have also been implicated in protein digestibility as it form complexes and also by interacting with enzymes such as trypsin and pepsin. Phytate as a very stable and potent chelating food component is considered to be an anti-nutrient by virtue of its ability to chelate divalent minerals and prevent their absorption [43]. The oxalate content ranged from 0.91 to 2.64 mg/100. There were no significant different (P>0.05) in oxalate content between sample A and C but differed significantly (P<0.05) from sample B. However, sample B (*Jatropha curcas* leaves) contains the highest mean value (2.64 mg/100 g) while sample C (Pap/*Jatropha curcas* leaves) had the minimum value (0.91 mg/100 g). These values were also similar to the research work of Abioye [31] who observed the oxalate content of 0.90 in maize pap fortified with vegetables. Oxalates affects calcium and magnesium metabolism and react with proteins to form complexes which have an inhibitory effect in peptic digestion [44]. Kidney stone patients who form calcium oxalate-containing stones are advised to limit their intake of foods which contain 410 mg oxalate per serving, with total oxalate intake not to exceed 50–60 mg/day. Oxalate can be reduce significantly by cooking, malting, soaking, dehulling and other heat treating methods [45]. The cyanide content for sample A, B and C were 0.00, 2.01 and 1.65 mg/100 g. The hydrogen cyanide content in this study ranged from 0.00 to 2.01 mg/100 g with sample B (*Jatropha curcas* leaves) having the highest mean value while sample A (pap) had no hydrogen cyanide. Although all samples differed significantly (P<0.05) from each other. The result was lower than 3.14 mg/100 g in fortified maize pap as was reported by Abioye [31]. The variation could be as a result of the nature of the sample and processing period. HCN is very toxic at high concentration to animals. HCN can cause dysfunction of the central nervous system, respiratory failure and cardiac arrest [44]. The result of the glycosides ranged from 0.00 to 2.01 mg/100 g. The Glycosides content of this sample was highest in sample B (2.01 mg/100 g) and lowest in sample A (0.00). There was a significant difference among all the samples (P<0.05). This result has also revealed that pap alone had no glycoside, however the presence of the compound in fortified pap was due to addition of *Jatropha curcas* leaves. Glycosides have been associated with thyroid enlargement and growth retardation as well as problems with the kidney and pancreas [46]. The result showed that the saponin mean values ranged from 0.00 to 1.24 mg/100 g. There were no saponin in pap but due to addition of *Jatropha curcas* leaves the fortified pap had a 0.28 mg/100 g of saponin. Although, sample B had the highest saponin content with the value of 1.24 mg/100 g than sample C with 0.28 mg/100 g but both samples differed significantly (P<0.05) from each other. Saponins reduce the uptake of certain nutrients including glucose and cholesterol at the gut through intraluminal physicochemical interaction. Hence, it has been reported to have hypocholesterolemic effects and thus they may aid in lessening the metabolic burden that would have been placed on the liver [47].

4. CONCLUSION

The study revealed that there was an increase in iron, magnesium and zinc which shows that fortification of pap with *Jatropha curcas* leaf is possible and this will also enhance the iron status of the populace especially the children that are at high risk of anaemia. The anti-nutrients of the fortified samples were within the acceptable limit while the functional properties revealed the flour could be used in bakery industry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. McLean E, Cogswell M, Egli I, Wojdyla D, De-Benoist B. Worldwide prevalence of anemia, WHO vitamin and mineral nutrition information system, 1993–2005. Public Health Nutrition. 2009;12(04):444–454.
2. Beard JL. Why iron deficiency is important in infant development. Journal of Nutrition. 2008;13(8):2534–2536.
3. Ram K, Chandyo, Manjeswori U, Ramesh K, Adhikari HS, Tor AS. Prevalence of iron deficiency and anaemia among young children with acute diarrhea in Bhaktapur, Nepal, Healthcare. 2015;3(1):593-606.

4. Pikuda OO, Ilelaboye NO. Proximate and chemical composition of PAP prepared from whole and powdered grains (Maize, Sorghum and Millet). Annals of Biolpapcal Research. 2013;4(7):239-242

5. Esther L, Charles AO, Adeoye OS, Toyin OA. Effects of drying method on selected properties of pap (Gruel) prepared from sorghum (*Sorghum vulgare*), Millet (*Pennisetum glaucum*) and Maize (*Zea mays*). Journal of Food Process Technology. 2013;4(248):1-4.

6. Shubhangi P, Dipanshu C. Food fortification and enrichment. International Journal of Basic and Applied Biology. 2014;2(3):166-168.

7. Azubike NC, Okwuosa CN, Achukwu PU, Maduka TC, Chike O. Acute toxicity and histopatholpapcal effects of crude aqueous extract of *Jatropha curcas* leaves in mice. Research Journal of Medicinal Plant. 2015; 9(7):340-346.

8. Ngwa NN. Chemical composition of some indigenous vegetables *Jatropha aconitifolia* and *Colocasia esculenta* and effect of their extract on the zinc, iton and vitamin A metabolism in rats. An M.Sc thesis submitted to the Department of Home Science, Nutrition and Dietetics, University of Nigeria Nsukka, Nigeria; 2007.

9. Abioye VF, Aka MO. Proximate composition and sensory properties of *moringa* fortified maize-pap. Journal of Nutrition and Food Science. 2015;12(1):2-4.

10. George OS, Wariboko ON, Nwachukwu C. Effect of *Jatropha Curcas* as feed additive on growth performance and carcass characteristic of weaned rabbit. Advance in Agriculture and Biology. 2016;4(4):82-85.

11. AOAC. Official Methods of Analysis (14th Ed.). Association of Official Analytical Chemists, Washington, DC; 2010.

12. Pearson IO. Fundamental of Food Biochemistry, 2nd Ed, Atlanta, Georgia, 30322 USA; 1976.

13. Available:www.en.wikipedia.org/wiki/specia

14. ITraese GE, Evans WC. Phamacognocy. 14th Ed. Brown Publication. London. 1989;30-34.

15. Harbourne JB. Phytochemical methods: A guide to modern technique of plants analysis. Chapman and Hall: London. 1983;60-64.

16. Wang JK, Filled SM. Food quality evaluation. An Approach Lan. Lancet Press. 1980;123–130. Available:http://jds.fass.org/cgi/pmidlookup?view=long&pmid=17106105

17. Suree N, Surat K, Akekachai N. Phytate and fiber content in Thai fruits commonly consumed by diabetic patients. Journal of Medical Association, Thai. 2004;87(1): 1444-6. Available:http://www.medassocthai.org/journal

18. AOAC. Association of official analytical chemist. Official methods of Analysis, Washington, D. C; 2000.

19. Sosulski FW, Garatt MO, Slinkard AE. Functional properties of ten legume flours. International Journal of Food Science and Technology. 1976;9:66–69. [Google Scholar]

20. Tharise N, Julianti E, Nurminah M. Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour. International Food Research Journal. 2014;21(4):1641-1649.

21. Udoro EO, Kehinde AT, Olasunkanmi, SG, Charles TA. Studies on the physicochemical, functional and Sensory properties of gari processed from dried cassava chips. Journal of Food Process Technology. 2014;5(1):1-8.
    Okaka JC, Potter NN. Functional and storage properties of cow pea-wheat flour blends in bread making. Journal of Food Science and Technology. 1977;42:828–833. [CrossRef] [Google Scholar] DOI:10.1111/j.1365-2621.1977.tb12614.x
    Narayana K, Narsinga Rao MS. Functional properties of war and heat processed winged bean (*Psophocarpus tetragonolobus*) flour. Journal of Food Science.1982;42:534–538.
    [Google Scholar]

22. Beuchart AA. World food and nutrition problems. Cereal Food World. 1982; 27:562.

23. Okaka JC. Teach yourself sensory evaluation and experimentation. Ocjanco Academic Publishers, Enugu, Nigeria. 2010;68-70.

24. SPSS. SPSS statistics for windows, release 22.0. Statistical Package for Social Sciences (SPSS). Inc; USA; 2012.

25. Roger P, Armand AB, Elie F, Eric B, Michel P, Joelle L, Frédéric G. Nutritional composition of five varieties of pap commonly consumed in maroua (Far-North, Cameroon). Polish Journal of Food and Nutritional Science. 2015;65(3):183–190.

26. Edet UO, Ebana RUB, Okoro CU, Ekanemesang UM, Ikon GM, Ntukidem NW, Uduak EM. Changes in proximate composition of corn meal (Ogi) assisted with *lactobacillus* species. Journal of Advances in Microbiology. 2017;2(1):1-6.

27. Mensah JK, Okoli RI, Ohaju-Obodo JO, Eifediyi K. Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnology. 2008;7(14):2304-2309.

28. Farinde EO. Chemical and sensory properties of sieved and unsieved fortified pap. Nature and Science. 2015;13(1):49-53.

29. Ikya JK, Gernah DI, Sengev IA. Proximate composition, nutritive and sensory properties of fermented maize, and full fat soy flour blends for ―Agidill production. African Journal of Food Science. 2013; 7(12):446-450.

30. Abioye VF. Proximate composition and sensory properties of moringa fortified yellow maize-pap. African Journal of Food Science Research. 2015;3(1):155-159.

31. FAO/WHO/UNU. Human, vitamin and mineral requirements (Recommended dietary intakes): Report of a Joint food and agricultural organization, World Health Organization and United Nations University; 2002.
Available:www.net.int

32. Ndubuisi LC. Evaluation of food potentials of tigernut tubers (*Cyperus esculentus*) and its products (milk, coffee and wine). A research project report submitted to the Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka, Enugu State, Nigeria. 2009;76-84.

33. Christa LFW, Robert EB. Zinc for the treatment of diarrhoea: Effect on diarrhoea morbidity, mortality and incidence of future episodes. International Journal of Epidemiology. 2010;39 (1):63–69.

34. Usman OG, Ameh U, Alifa ON, Ameh MU. Vitamin and mineral evaluation of mixed fruit jam from blends of pineapple, orange and sourplum. Pakistan Journal of Food Science. 2015;25(3):137-143.

35. Oluseyi AK, Ajani O, Siyanbola TO, Akinsiku AA, Ajanaku CO, Oluwole O. Dietary fortification of sorghum-pap using crayfish (*Paranephrops planifrons)* as supplements in infancy. Food Science and Quality Management. 2013;15(1):1-9.

36. Singh U. Functional properties of grain legume flours. Journal of Food Science and Technology. 2001;38(3):191-199.

37. Odunlade TV, Taiwo KA, Adeniran HA. Functional and antioxidative properties of sorghum pap flour enriched with cocoa. Annals Food Science and Technology. 2016;2(1):497-506.

38. Kaushal P, Kumar V, Sharma HK. Comparative study of physico-chemical, functional, anti-nutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*), pegion pea (*Cajanus cajan*) flour and their blends. LWT-Food Science and Technology. 2012;48(6):59-68.

39. Suresh CS. Assessment of functional properties of different flours. African Journal of Agricultural Research. 2013; 8(38):4849-4852.

40. Gernah DI, Ariahu EU, Umeh. Physical and microbilogocal evaluation of food formulations form malted and fermented maize (*Zea mays* L.) fortified with defatted sesame (*Sesamun indicum L.)* flour. Advance Journal of Food Science and Technology. 2012;4(3):148–154.

41. Allonso R, Aguirne A, Marzo F. Effects of traditional processing methods on anti-nutritional and *in-vitro* digestibility of protein and starch in faba and kidney beans. Food Chemistry. 2000;68(3):159-165.

42. Amadike EU, Emmanuel IA, Friday OU, Chinyere GC, Ositadinma CU, Kayode AO. Nutritional and chemical composition of *Jatropha curcas* (L) seed oil from Nigeria. International Journal of Biosciences. 2013; 3(5):125-134.

43. Akande KE, Doma UD, Agu HO, Adam HM. Major antinutrients found in plant protein sources: Their effect on nutrition. Pakistan Journal of Nutrition. 2010;9(8): 827-832.

44. Weiwen C, Liebman M. Short communication oxalate content of legumes, nuts, and

grain-based flours. Journal of Food Composition and Analysis. 2005;18(1): 723–729.

45. Onuekwe ME. Chemical composition of some lesser-known wild fruits and vegetables consumed in Ayamelum Local Government Area of Anambra State. A Project Report for the Degree of Masters of Science in Human Nutrition. Department of Home Science, Nutrition and Dietetics Faculty of Agriculture, University of Nigeria, Nsukka, Enugu State, Nigeria. 2012;55-56.

46. Ali A. Major antinutrients and phytochemical investigation found in an Iranian edible plant source. Journal of Nature Production Plant Resources. 2011; 1(2):56-61.

47. Ihegboro GO, Ononamadu CJ, Afor E, Odogiyan GD. Cytotoxic and hepatocurative effect of aqueous fraction of *Tapinanthus bangwensis* against paracetamol-induced hepatotoxicity. Journal of Evidence-Based Integrative Medicine. 2018;23.
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