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Evaluation of Nutrient Content and Acceptability of Pawpaw (*Carica papaya*) Soups Consumed by Tiv People of Benue State, Nigeria

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Abstract: *Carica papaya* (Pawpaw), a tropical plant with inexpensive fruit is underutilized and highly consumed in the ripe form in Nigeria. The fruit is reportedly high in niacin, vitamin C and calcium, with therapeutic properties. The matured unripe fruit is sliced, dried and cooked into soups by Tiv people of Benue State, Nigeria. The study was carried out to determine the nutrient, antinutrient and sensory attributes of three local soups prepared from unripe Pawpaw fruit as consumed by Tiv people. Fresh matured unripe Pawpaw fruit was obtained from Department of Agronomy, University of Ibadan research farm, washed, peeled, sliced into chips and sun-dried. Sun-dried chips were rehydrated and prepared into three (*Poucho*, Tomato and *Egusi)* soups. Fresh Pawpaw fruit (PF), dry pawpaw chips (PC), *Poucho* (PS) and *Egusi* (ES) soups, and tomato stew (TS) were analysed for proximate, mineral, vitamin and anti-nutrient composition using standard methods of AOAC. Sensory attributes were evaluated using 30 panelists on nine-point hedonic scale. Dry PC and soups contained 12.0-55.2g moisture, 3.84-8.74g crude protein, 0.3-7.1g crude fat, and 82.1-24.6g carbohydrates /100g sample. Tomato stew was highest in carbohydrate, PS highest in crude fat, ES in protein and energy. The soups were rich in both macro and microminerals, with ES having highest values. The three soups were rich in beta-carotene, vitamins C and E, and low in antinutrients. The soups were acceptable to the panelists, and are hence, recommended for improving dietary diversity, antioxidant and micronutrient intake of consumers.

Keywords: Unripe Pawpaw Fruit, Nutrient Content, Antinutrients, Sun-Drying, Pawpaw Soups

Introduction

Micronutrient malnutrition is a devastating problem in Nigeria, not only to its people, but also to its security and economy. Large segment of population in Nigeria is suffering from micronutrient deficiency in spite of abundant tropical fruits in the country [1]. Pawpaw (*Carica papaya*) is a common and well-known tropical plant that grows abundantly both wild and domesticated in Nigeria with inexpensive fruit. Its fruit, with vernacular names *Gwandar gida* (Hausa), *Mgbimgbi* (Igbo), *Ibepe* (Yoruba), and *Mbuawe* (Tiv) is one of the cheapest fruits grown and consumed in Nigeria.

Fresh pawpaw fruit which is rich in minerals and vitamins, with therapeutic properties for prevention and management of chronic non-communicable diseases is widely consumed, as it is available all year round, with its peak towards the end of raining season. The fruit has been reported to be higher in niacin and calcium than apples, oranges and bananas; and has three times as much vitamin C as apples, two times as much as bananas and 1/3 as much as oranges [2]. In addition, it is a good source of antioxidants, energy and dietary fibre [2]. The ripe fruits are eaten as food, and used for production of smoothies and juices while the latex is used to cure fever, beriberi, and its infusion used to cure stomach-ache [3].

In Nigeria, Pawpaw is still underutilized when compared with other fruits such as oranges and mangos; and is only consumed as ripe fruit. The Tiv tribe of Benue State of Nigeria process the unripe fruits into chips or flakes used for soup preparation. Little or no commercial products such as juice or jam is made from the fruit, and with inadequate storage facilities, there is high post-harvest loss of the ripe fruit annually. In sub-Saharan Africa there is dearth of information on nutritional benefits of many indigenous fruits, vegetables, and soups due to limited research them [4]. These food items are part of the traditional food systems that improve dietary diversity, but are being neglected due to nutrition transition. To tackle micronutrient malnutrition traditionally therefore, there is need to exploit effective utilization of indigenous foods that promote dietary diversity in sub-Saharan Africa [4].

Most researches carried out on unripe pawpaw fruit have been tailored towards its non-food usage [2, 5, 6]. This study was carried out to determine the nutrient and anti-nutrient contents, and acceptability of unripe Pawpaw soups as a means of promoting dietary diversity of indigenous foods.

Materials and Methods

Sample Collection and Preparation

Matured unripe Pawpaw fruits (*Solo* variety) were obtained from the farm of Department of Agronomy, University of Ibadan, Ibadan, Nigeria. Local ingredients needed for the soups (*Yeyeh*, *Tsamiya*, *Gbaye*) were obtained from Makurdi modern market, Makurdi, Benue State and Bodija market, Ibadan,

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Oyo State, Nigeria. The Pawpaw chips were prepared as shown below:

Matured unripe Pawpaw fruits
↓
Sunning for one hour
↓
Washing
↓
Peeling
↓
Deseeding/cavity cleaning
↓
Slicing into tiny chips
↓
Sun-drying of the chips
↓
Packaging

Figure 1: Flow chart for production of unripe Pawpaw fruits chips

Figure 2: Matured unripe Pawpaw fruits undergoing sunning for one hour.

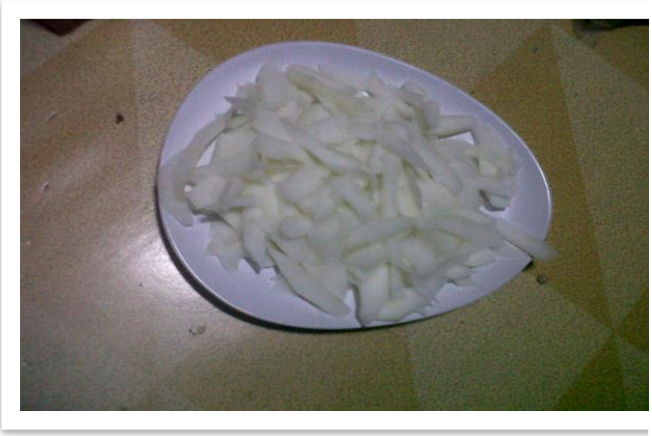

Figure 3: Freshly prepared Pawpaw chips before Sun-drying.

Soup preparation

The soups were prepared in the Dietetic kitchen of Department of Human Nutrition and Dietetics, University of Ibadan. Three types of soups were prepared from sun-dried Pawpaw chips traditionally as consumed by the *Tiv* people of Benue State using the recipes shown in Table 1.

Thirty grammes (30 g) each of dry Pawpaw chips was soaked in 1.5 litres of tap water with a pinch of salt for an hour, drained and treated as follows.

1. *Poucho* Soup: Palm oil (30 g) was added to 500 mL of boiling water in a pot and allowed to cook for about 10 min. Blended ingredients (*Yeyeh*, *Gbaye*, *Tsamiya*, pepper, ginger, onion, and locust bean) were added in the proportion shown in Table 1 and allowed to cook for another 10 min. Salt and bouillon cubes were added and allowed to cook for a minute, followed by addition of drained Pawpaw chips, 1000 mL of distilled water and then allowed to cook for 10 min, and labelled sample PS (Figure 4).

2. Tomato stew: Palm oil (60 g) was heated in a pot, and blended tomatoes, pepper and onion added and fried. About 500 mL water was added to the fried stew and allowed to cook for 3 min. The blended *Yeyeh*, *Gbaye*, *Tsamiya*, ginger, and locust bean, together with salt and bouillon cubes were added and allowed to cook for 5 mins. Drained Pawpaw chips and 1000 mL of distilled water were added to the stew and allowed to cook for 10 min. This was labelledsample TS (Figure 5).

3. *Egusi* (Melon) soup: A thick paste of *Egusi* (melon seed) was made by adding little water to grinded *Egusi* in a clean bowl, continuously mixing it until oil appeared and allowed to rise. Palm oil was heated and blended pepper and onions were added to it and fried. Then, 1000 mL of distilled water was added and allowed to cook for 3 min. *Yeyeh*, *Gbaye*, *Tsamiya*, ginger and locust bean, together with salt and bouillon cubes were added and allowed to cook for 5 min. The *Egusi* paste was then added in small portion at a time and allowed to cook for 6 min. The drained Pawpaw chips alongside 500 mL of distilled water was added and allowed to cook for 10 min. This was labelled sample ES (Figure 6).

Table 1: Recipe composition of Pawpaw soups and stew

Ingredients	*Poucho* soup (g)	Tomato stew (g)	*Egusi* soup (g)
Dry Pawpaw chips	30	30	30
Egusi (*Colocynthis citrullus*)	-	-	1200
Dry *Gbaye* (*Prosopis africana*)	5	2.5	2.5
Tsamiya seeds (*Tamarindus indica*)	5	2.5	2.5
Dry black pepper (*Yeyeh*)	5	2.5	2.5

Fresh Locust Beans	30	10	10
Fresh tomatoes	-	600	-
Bouillon Cubes	6	6	6
Fresh Pepper	25	25	25
Fresh ginger	6	6	6
Crayfish	2.8	10	40
Onion	280	100	100
Salt	10	10	10
Palm Oil	30	60	60
Water (l)	1.5	1.5	1.5

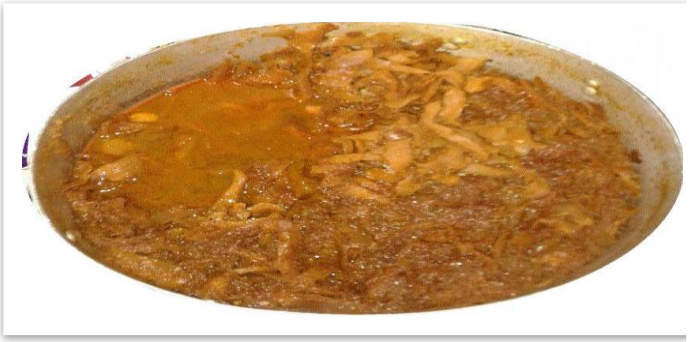

Figure 4: Pawpaw *Poucho* Soup (Sample PS)

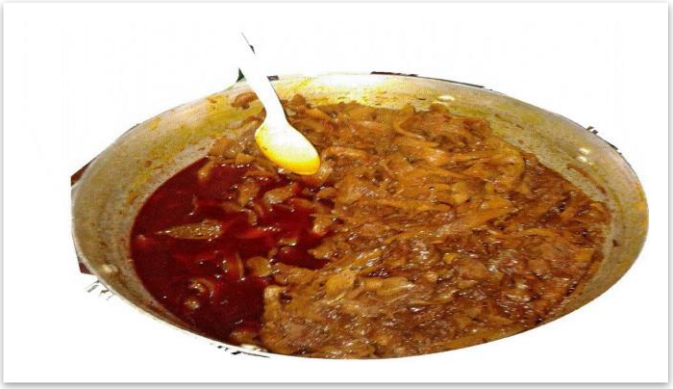

Figure 5: Pawpaw Tomato Stew (Sample TS)

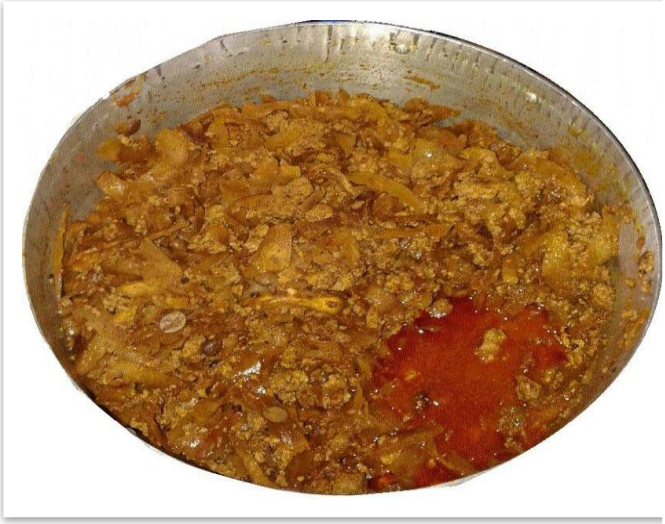

Figure 6: Pawpaw *Egusi* Soup (Sample ES)

Chemical Analysis

Proximate Composition Determination

Proximate composition of the samples was determined using the standard methods of AOAC 2005 [7]. The moisture content of the samples was determined by air oven method (Plus 11 Sanyo Gallenkamp PLC UK) at 105 ^{0}C for 4 hours. The crude protein was determined using micro-Kjeldahl method (Method No. 978.04), crude lipid was determined by Soxhlet extraction method (Method No. 930.09), while the ash content was determined through incineration in muffle furnace set at 550 ^{0}C for 4 hours (Method No. 930.05). The total carbohydrate content was obtained by difference, and gross energy content of the samples determined by using ballistic bomb calorimeter. All analyses were carried out in triplicate.

Mineral Content Determination

The mineral contents of the samples were determined through AOAC, (2005) standard methods [7]. Potassium and sodium content of the samples were determined by digesting the ash of the samples with perchloric acid and nitric acid, and their concentration determined by taking the readings of their solutions on Jenway digital flame photometer/spectronic20 (Method No. 975.11). Phosphorus was determined by Vanado-molybdate colorimetric method (Method No. 975.16). Calcium, magnesium, iron, zinc, manganese, copper and selenium content of the samples were determined by atomic absorption spectrophotometric method (Buck Scientific, Norwalk, USA) and compared with absorption of standards of these minerals (Method No. 975.23).

Vitamin Content Determination

Beta-carotene Determination: The beta-carotene content of the samples was determined through ultraviolet absorption measurement at 328 nm after extraction with chloroform. Calibration curve of vitamin A acetate was made and sample β-carotene concentration read and estimated as microgram (µg) of vitamin A acetate.

Thiamine (Vitamin B_1) Determination: Thiamine content of the samples was determined by weighing 1g of sample into 100 mL volumetric flask with

addition of 50 mL of 0.1M H_2SO_4 and boiled in a boiling water bath with frequent shaking for 30 minutes. Five millilitres (5 mL) of 2.5M sodium acetate solution was added and flask set in cold water to cool contents below 50 ^{0}C. The flask was stoppered and kept at 45-50 ^{0}C for 2 hours and thereafter made up to 100 mL mark. The mixture was filtered through a No. 42 Whatman filter paper, discarding the first 10 mL. Ten millilitres (10 mL) was pipetted from remaining filtrate into a 50 mL volumetric flask, and 5 mL of acid potassium chloride solution added with thorough shaking. Standard thiamine solutions were prepared and treated same way. The absorbance of the samples as well as that of standards was read on a fluorescent UV Spectrophotometer (Cecil A20 Model) at a wavelength of 285 nm.

Riboflavin (Vitamin B_2) Determination: One gramme (1 g) of each sample was weighed into a 250 mL volumetric flask, 5 mL of 1M HCl was added, followed by the addition of 5 mL of dichloroethene. The mixture was shaken and 90 mL of distilled water was added. The whole mixture was thoroughly shaken and was heated on a steam bath for 30 mins to extract all the riboflavin. The mixture was then cooled and made up to volume with distilled water. It was then filtered, discarding the first 20 mL of the aliquot. Two millilitres (2 mL) of the filtrate obtained was pipetted into another 250 mL volumetric flask and made up to mark with distilled water. Samples were read on the fluorescent spectrophotometer at a wavelength of 460 nm. Standard solutions of riboflavin were prepared and readings taken at 460 nm. The sample riboflavin was obtained through calculation.

Niacin (Vitamin B_3) Determination: Five grammes (5 g) of sample was extracted with 100 mL of distilled water and 5 mL of this solution was drawn into 100 ml volumetric flask and made up to the mark with distilled water. Standard solutions of niacin were prepared and absorbance of sample and standard solutions was measured at a wavelength of 385 nm on a spectrophotometer, and niacin concentration of the sample estimated.

Pantothenic Acid (Vitamin B_5) Determination: Pantothenic acid content of the samples was determined by extracting 1g of sample with distilled water, filtered, and 5 mL of aliquot of the sample filtrate thoroughly mixed with 5 ml of 12% KBr and 10ml of $KMnO_4$ solutions. The mixture was warmed in a boiling water bath for 10 mins, cooled in ice for 5 mins and 20% freshly prepared H_2SO_3 solution added dropwise to obtain colourless solution. To the colourless solution, 10 mL of 2, 4 - dinitrophenyl hydrazine (5 g/l) was added and mixed thoroughly. The mixture was heated on a steam bath for 15 mins and cooled to room temperature to obtain yellow precipitate. The precipitate was dried for 30 mins in an oven set at 100 ^{0}C and dissolved in hot pyridine solution with thorough mixing. The suspension was filtered through Whatman No. 42 filter paper into a 50 mL volumetric flask and made up to mark with pyridine solution. To this solution was added 50 mL distilled water, followed by addition of 5 mL of 5M NaOH solution. The absorbance of the samples and standard solutions of panthothenic acid were read on a spectronic21D spectrophotometer at 570 nm, and sample concentration calculated in µg /100 g of sample.

Pyridoxine (Vitamin B_6) Determination: Vitamin B_6 content of the samples was determined by extracting 1 g of sample with 0.5 g of ammonium chloride, 45 mL of chloroform and 5 mL of absolute ethanol. The mixture was thoroughly mixed in a separating funnel by shaking for 30 mins, and 5 mL of distilled water added. The chloroform layer containing the pyridoxine was filtered into a 100 mL volumetric flask and made up to the mark with chloroform. Standard solutions of 0-10 ppm of vitamin B_6 were prepared and treated in a similar way as samples; and their absorbance measured on Cecil 505E spectrophotometer at 415 nm. The amount of vitamin B_6 in the samples was then calculated.

Folic Acid (Vitamin B_9) Determination Folic acid content of the samples was determined by weighing 1g of each sample into a 250 mL volumetric flask, followed by addition of 100 mL of distilled water and spinned or shaken for 45 mins. The mixture was then made up to mark with distilled water. The mixture was filtered into another 250 mL beaker, rejecting the first 20 mL. To another 20 mL filtrate, 5 mL of 1% sodium dithionite solution was added to decolorize the yellow colour. Standard solutions (0 – 10 µg / mL) of folic acid were prepared from folic acid stock. The absorbance of solutions of standard and sample were read at 445 nm on spectronic21D spectrophotometer and folic acid concentration calculated.

Cyanocobalamin (Vitamin B_{12}) determination: Cyanocobalamin content of the samples was determined by extracting 1 g of sample with distilled water with shaking for 45 mins, followed by filtering the mixture. The first 20 mL of the filtrate was rejected, and another 20 mL filtrate collected. To the collected filtrate, 5 mL of 1% sodium dithionite solution was added. Standard cyanocobalamin solutions (0-10 µg/mL) were prepared, and absorbance of sample as well as standards was read on spectronic21D spectrophotometer at 445 nm. The amount of sample cyanocobalamin was then estimated through calculation.

Ascorbic acid Determination: Ascorbic acid in the samples was determined by titrating the aqueous extract of each sample with solution of 2, 6 – dichlorophenol-indophenol dye to a faint pink end point.

Tocopherol (Vitamin E) determination: One gramme of sample was weighed into a 250 mL conical flask fitted with a reflux condenser wrapped in aluminium foil, and refluxed with 10 mL of absolute ethanol and 20 mL of 1M ethanolic sulphuric acid for 45 min. The resultant solution was cooled for 5 min, followed by addition of 50 mL of distilled water and then transferred into a separating funnel covered with aluminium foil. The unsaponifiable matter in the mixture was extracted with 5 × 50 mL diethyl ether. The combined extract was washed free of acid and dried over anhydrous sodium sulphate. The extract was later evaporated at a low temperature and the residue obtained immediately dissolved in 10 mL absolute ethanol. Aliquots of solutions of the samples and standards were transferred to a 20 mL volumetric flask, 5 mL absolute ethanol added, followed by a careful addition of 1 mL conc. HNO_3, placed on water bath at 90 ^{0}C for exactly 30 mins from the time the ethanol begins to boil and then rapidly cooled under running water. The absorbance of sample solutions was read at 470 nm (Method No. 1893) (AOAC, 2005) [7].

Anti-nutrient Determination

The alkaloid content of the samples was determined by weighing 2 g of finely grinded sample into 100 mL beaker and 20 mL of 80% absolute ethanol added to give a smooth paste. The mixture was transferred to 250 mL flask, more ethanol added to make up to 100 mL, with 1 g magnesium oxide added. The mixture was digested under reflux condenser with occasional shaking for 1.5 h in boiling water bath, filtered while hot and the residue redigested for 30 min with 50 mL ethanol, after which the ethanol was evaporated and hot water added to replace the loss. After evaporation of all ethanol, 3 drops of 10% HCl was added. The whole solution was then transferred into a 250 mL volumetric flask, followed by addition of 5 mL acetate solution and 5 mL of potassium ferrocyanide solutions and thoroughly mixed to give homogenous solution.

The flask was allowed to stand for a few minutes and filtered through dry filter paper. Ten millilitre (10 mL) of the filtrate was transferred into a separating funnel and the alkaloid present extracted vigorously by shaking with five successive portions of chloroform. The residue obtained was dissolved in 10 mL hot distilled water and transferred into Kjedahl tube with the addition of 0.02 g sucrose, 10 mL concentrated H_2SO_4, 0.02 g selenium, and digested to a colourless solution. The percent nitrogen was determined and converted to % total alkaloid by multiplying by a factor of 3.26 (i.e. Total alkaloid = % N x 3.26).

Oxalate content of the samples was determined by extraction of the samples with water for about 3 h and standard solutions of oxalic acid prepared and read on spectrophotometer (Spectronic20) at 420 nm. The absorbance of the samples was also read at 420 nm, and amount of oxalate estimated.

The tannin content of the samples was determined by extracting the samples with a mixture of acetone and acetic acid for 5 h, measuring their absorbance and comparing the absorbance of the sample extracts with absorbance of standard solutions of tannic acid at 500 nm on spectronic20 [8]. Saponin was also determined by comparing the absorbance of the sample extracts with that of the standard solutions at 380 nm [9]. All determinations were carried out in triplicate.

Papain Content Determination

The samples papain was extracted by adding 0.50 g of grinded sample to 100 mL of 0.1M sodium hydrogen phosphate buffer (pH 6) and mixed thoroughly. The suspension obtained was centrifuged at 5000 rpm in Gerber centrifuge (Gallenkamp Model) at 5 ^{0}C for 30 min, decanted into 30 mL centrifuge stopper and stored in a deep freezer at – 20 ^{0}C prior to analysis. One millilitre (1 ml) of enzyme extract was mixed with 1M parahydroxyl benzoic acid and 5 mL of 0.1M sodium phosphate buffer (pH 5.5). One millilitre (1ml) of 0.3% hydrogen peroxide (H_2O_2) was added to provide a uniform suitable transfer to a clean cuvette for absorbance/optical density determination. Standard solutions of papain enzyme extract (10 – 15 mg/L) were prepared and treated as sample extract of enzyme. The percent papain was calculated as:

$$\% \text{ Papain} = \frac{\text{Absorbance of sample x gradient factor x dilution factor x 100}}{\text{Weight of sample taken}}$$

Sensory Evaluation of Pawpaw Soups

Acceptability study of prepared Pawpaw soups was carried out at the Department of Human Nutrition and Dietetics sensory evaluation laboratory. Coded samples of the Pawpaw soups were assessed using thirty (30) untrained panelists drawn within the University community. They were instructed to observe and score the colour, aroma, taste, texture and general acceptability of the soups using a 9-point hedonic scale. The degree to which a product is relished was expressed as: like extremely (9), like very much (8), like moderately (7), like slightly (6), neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2), dislike extremely (1).

Statistical Analysis

The mean of the data obtained from chemical analyses of samples were subjected to independent t-test, and the mean of data from sensory evaluation subjected to ANOVA at $p < 0.05$. Tukey's test was used to separate the means as described by [10, 11].

Results

Proximate Composition of Raw and Processed Samples

The proximate composition of fresh Pawpaw fruit, dried chips and cooked soups from Pawpaw are shown in Table 2. Moisture constituted more than three-quarter part of the fresh unripe Pawpaw fruit (Sample PF), while total carbohydrates constituted about one-fifth part. The fresh fruit was very low in crude protein, fat and gross energy content.

Sun drying significantly reduced the moisture content of Pawpaw in the dried chips (PC) compared with the fresh fruit, leading to highly significant increase ($p<0.05$) in the crude protein, fat, carbohydrate and gross energy content of the sample. However, cooking the dried Pawpaw chips to soups and stew significantly increased the proximate composition and gross energy contents of the samples compared with the fresh fruit and dried chips. Dried chips had the highest carbohydrate and gross energy value, *Egusi* soup (ES) was highest in protein content, while *Poucho* soup (PS) had the highest fat and ash values. Among the prepared soups, the Tomato stew (TS) had the highest carbohydrate content.

Table 2: Proximate composition of Raw fruit, Dry chips and Pawpaw soups (g/100g)*

Parameter	PF	PC	PS	TS	ES
Moisture	79.15±0.04^a	12.03±0.00^b	53.64±0.02^c	55.19±0.04^d	54.86±0.04^e
Crude Protein	0.21±0.01^a	3.84±0.13^b	8.48±0.08^c	6.87±0.06^d	8.74±0.04^e
Crude Fat	0.04±0.00^a	0.33±0.01^b	7.06±0.01^c	5.74±0.02^d	6.60±0.01^e
Ash	0.05±0.01^a	1.97±0.02^b	1.31±0.01^c	1.23±0.01^d	1.35±0.01^e
Total Carbohydrates	20.55±0.02^a	81.83±0.18^b	29.51±0.09^c	30.97±0.04^d	28.45±0.01^e
Gross Energy (kcal/)	84.83±0.00^a	345.65±0.01^b	184.52±0.21^c	163.95±0.32^d	188.06±0.03^e

Values with the same superscript on the same row are not significantly different (p> 0.05)

***Values are means and the standard deviations of three determinations (n = 3)*

PF = Fresh Matured Unripe Pawpaw Fruits; **PC** = Dry Pawpaw Chips; **PS** = *Poucho* Soup;
TS = Tomato Stew; **ES =** *Egusi* Soup.

Mineral Composition of Raw and Processed Samples

In Table 3, fresh unripe Pawpaw fruit (Sample PF) was very low in sodium, potassium, calcium, magnesium and phosphorus content; and low in iron, zinc, copper and manganese. However, sun drying led to highly significant increase in mineral content of the chips ($p<0.05$). Sample PC had the highest values for all the minerals studied.

Among the soups prepared, *Egusi* soup had the highest value for sodium, potassium, phosphorus, iron, zinc, copper and manganese; while the *Poucho* soup was highest in calcium and magnesium content. There was no significant difference in sodium, potassium, calcium and magnesium contents of the *Poucho* and *Egusi* soups ($p>0.05$), while there was significant difference in phosphorus, iron, zinc, copper and manganese contents of the two soups, *Egusi* soup having higher values ($p<0.05$). Except for selenium, the P*oucho* and *Egusi* soups were significantly different in mineral contents compared with the Tomato stew ($p<0.05$). Among the soup samples, Tomato stew sample had the lowest mineral content.

Table 3: Mineral composition of Raw fruit and processed samples (mg/100g 'As consumed')*

Parameter	PF	PC	PS	TS	ES
Sodium	6.04±0.06^a	251.50±1.23^b	173.32±1.05^c	149.68±0.95^d	173.95±0.69^c
Potassium	24.17±0.27^a	608.66±0.54^b	384.32±0.70^c	340.62±0.95^d	384.94±0.69^c
Calcium	11.56±0.04^a	396.40±0.19^b	258.71±0.07^c	225.42±0.06^d	256.51±0.01^c
Magnesium	0.29±0.01^a	277.36±1.86^b	206.30±0.70^c	181.58±0.63^d	205.62±0.69^c
Phosphorus	6.91±0.42^a	332.56±1.86^b	232.65±0.18^c	242.00±0.09^d	280.16±0.11^e
Iron	0.21±0.01^a	15.21±1.86^b	8.75±1.05^c	7.59±0.62^d	9.14±1.03^e
Zinc	0.25±0.01^a	4.96±0.01^b	3.24±0.01^c	2.74±0.01^d	3.33±0.01^e
Copper	0.05±0.01^a	2.16±0.01^b	1.60±0.01^c	1.18±0.01^d	1.65±0.01^e
Manganese	0.04±0.01^a	1.87±0.02^b	1.54±0.01^c	1.05±0.01^d	1.59±0.01^e
Selenium (µg/)	0.00±0.00^a	0.03±0.01^b	0.02±0.00^c	0.02±0.01^c	0.02±0.01^c

Values with the same superscript on the same row are not significantly different (p> 0.05)

***Values are means and the standard deviations of three determinations (n = 3)*

PF = Fresh Matured Unripe Pawpaw Fruits; **PC** = Dry Pawpaw Chips; **PS** = *Poucho* Soup;
TS = Tomato Stew; **ES =** *Egusi* Soup

Vitamin composition of Raw and Processed Samples

Fresh Pawpaw fruit was rich in beta carotene, ascorbic acid and α-tocopherol, but low in B-vitamins (Tables 4). Sun drying significantly increased the beta carotene and vitamin E content of the dried chips

with significant reduction in B-vitamins and ascorbic acid contents compared with the fresh fruit sample ($p<0.05$). Cooking the chips into soups and stew significantly increased both fat-soluble and water-soluble vitamins compared with both fresh and sun-dried samples ($p<0.05$). Significant differences were also observed between the vitamin contents of the soups and stew ($p<0.05$). Over all, *Poucho* soup had the highest vitamin content among the soups ($p<0.05$).

Table 4: Vitamin composition of Raw fruit and processed samples (mg/100g fresh weight)*

Parameter	PF	PC	PS	TS	ES
β-Carotene (µg/)	855.55±0.21^{a}	1786.6±0.42^{b}	3968.50±0.00^{c}	3794.90±0.07^{d}	3862.6±0.21^{e}
Thiamine	0.93±0.01^{a}	0.38±0.02^{b}	0.73±0.01^{c}	0.50±0.02^{d}	0.59±0.04^{e}
Riboflavin	0.16±0.01^{a}	0.08±0.01^{b}	0.28±0.02^{c}	0.19±0.01^{a}	0.24±0.01^{c}
Niacin	0.66±0.03^{a}	0.28±0.01^{b}	0.97±0.02^{c}	0.78±0.04^{d}	0.87±0.03^{e}
Panthotenic acid	0.34±0.00^{a}	0.22±0.01^{b}	0.55±0.01^{c}	0.34±0.02^{a}	0.44±0.02^{d}
Pyridoxine	0.86±0.04^{a}	0.56±0.04^{b}	1.54±0.03^{c}	1.27±0.01^{d}	1.43±0.07^{e}
Folic acid (µg/)	0.34±0.02^{a}	0.20±0.04^{b}	0.56±0.01^{c}	0.36±0.01^{a}	0.53±0.01^{c}
Cyanocobalamin	0.36±0.02^{a}	0.13±0.03^{b}	0.80±0.03^{c}	0.54±0.04^{d}	0.59±0.03^{d}
Ascorbic acid	35.91±0.02^{a}	21.40±0.02^{b}	41.91±0.02^{c}	37.53±0.04^{d}	38.34±0.04^{e}
Tocopherol (µg/)	9.55±0.35^{a}	12.25±0.21^{b}	32.66±0.35^{c}	19.00±0.42^{d}	22.41±0.35^{e}

Values with the same superscript on the same row are not significantly different ($p> 0.05$)
Values are means and the standard deviations of three determinations ($n = 3$).

Anti-nutrient and Papain Content of Raw and Processed Samples

The fresh Pawpaw fruit was very low in all the antinutrients studied (Table 5). Sun drying increased the antinutrient content in the dried sample but brought significant reduction in its papain content compared with the fresh fruit ($p<0.05$). Also, cooking the chips into soups and stew significantly increased the antinutrients but significantly reduced the papain content in the soups ($p<0.05$). There was no significant difference in the values of antinutrient contents of the soups, with Tomato stew having the lowest value for all antinutrients and papain.

Table 5: Anti-nutrient and Papain content of Raw fruit and processed samples (mg/100g)*

Parameter	PF	PC	PS	TS	ES
Alkaloid	0.04±0.01^{b}	0.32±0.00^{a}	0.07±0.01^{e}	0.05±0.00^{d}	0.11±0.00^{c}
Oxalate	0.01±0.00^{b}	0.11±0.01^{a}	0.04±0.00^{c}	0.03±0.00^{c}	0.04±0.00^{c}
Tannin	0.01±0.01^{a}	0.00±0.00^{a}	0.01±0.01^{a}	0.00±0.00^{a}	0.01±0.01^{a}
Saponin	0.02±0.02^{b}	0.26±0.01^{a}	0.03±0.00^{b}	0.03±0.01^{b}	0.04±0.01^{b}
Papain	4.89±0.04^{b}	1.74±0.08^{a}	0.33±0.01^{c}	0.28±0.04^{c}	0.38±0.01^{c}

Values with the same superscript on the same row are not significantly different ($p> 0.05$)
Values are means and the standard deviations of three determinations ($n = 3$)

Sensory Evaluation of the Soups and Stew

Among the soups and stew prepared from Pawpaw chips, *Egusi* soup was rated highest in all the parameters assessed (Table 6). The *Poucho* soup was rated higher in aroma, taste and texture than the Tomato stew, while the Tomato stew was scored higher in colour than the *Poucho* soup. There was no significant difference in scores for aroma and texture of the three soups. Also, there was no significant difference in scores for colour between Tomato stew and *Egusi* soup, and general acceptability of *Poucho* soup and Tomato stew. However, there was significant difference in taste of the three soups ($p<0.05$), *Egusi* soup scoring highest, followed by *Poucho* soup. In terms of general acceptability, all the soups were acceptable to the panelists, with *Egusi* soup being the most preferred.

Table 6: Sensory evaluation of Pawpaw soups and stew

Parameter	PS	TS	ES
Colour	6.5±1.14^{a}	7.1±0.98^{b}	7.4±1.06^{b}
Aroma	7.5±0.97^{a}	7.1±1.21^{a}	7.6±1.09^{a}
Taste	6.1±1.33^{a}	5.2±1.35^{b}	6.9±1.20^{c}
Texture	6.8±1.50^{a}	6.6±1.18^{a}	7.3±1.48^{a}
General Acceptability	6.5±0.97^{a}	6.5±1.25^{a}	7.8±1.33^{b}

Means with the same superscript within the same row are not significantly different ($p>0.05$)
PS = *Poucho* Soup; **TS** = Tomato Stew; **ES** = *Egusi* Soup.

Discussion

Proximate Composition of Fresh Fruit and Soups

The fresh unripe Pawpaw fruit was very high in moisture content. This is common with many fresh fruits reported in the literature [12, 2]. The moisture content of the fresh fruit reported in this study is similar to 80% reported for Pawpaw [2], but lower than 88% reported by Olarewaju [12]. This observed difference in value may be due to the fact that ripe fruits were used in their study, while unripe fruit was used in this study. The fruit was very low in protein content. This is in line with literature report that

many fruits are generally poor source of protein [13, 14, 15]. The value of crude protein reported in this study is similar to those reported by Olarewaju [12] and Nwofia *et al*., [16]. Also, the fruit contained negligible amount of fat. The fat content of the fresh sample was low when compared with the value obtained by Aravind *et al.*, [2] who also worked on raw Pawpaw fruit of the same solo variety. This could be due to geographic difference or seasonal variation in nutrient content of the samples. The ash content of the fruit was very low, signifying its low mineral content. Apart from moisture, carbohydrate was the next higher nutrient in Pawpaw fruit. The gross energy content significantly increased in the sun-dried chips compared with the fresh sample due to reduction in level of its moisture.

The observed significant loss in moisture content in the dried sample is similar to the findings of Arise *et al*., [17], Adepoju and Adefila, [18] who recorded significant loss in moisture content of fresh okra fruits when dried; and Akubor and Eze [19] who also reported significant loss in moisture content of sun-dried carrots. The increase in the protein content of the sun-dried chips with reduction in moisture content observed in this study is similar to the finding of Akubor and Eze [19] who also reported an increase in the protein content of sun-dried carrots. The fat content also increased in the chips as the moisture content reduced. This observed increase in fat content of the sun-dried chips is similar to reported increase in fat content of *Amaranthus hybridus* [21], and dried okra [18]; but different from reported decrease in fat content of dried carrots [19] attributed to be due to oven drying method employed in their study. Sun-drying Pawpaw fruit to chips resulted in significant increase in carbohydrate content of the chips. This observation is similar to the findings in the literature [18, 19].

There was significant increase in moisture content of the soups due to the soaking of the dried chips in water prior to its cooking, and addition of substantial amount of water during cooking. This is similar to the findings of Obiakor–Okeke *et al*., [20]. However, the moisture content of the soups is lower when compared with other values reported in the literature for vegetable soups [21, 22, 23, 24].

The increase in protein content of the soups and stew was believed to be due to addition of crayfish and locust bean used in preparing the soups and stew. Similar increases in protein content of soups prepared from *Ceiba pentandra* and crayfish [22], and *Amaranthus hybridus* soups and *Cirina forda* larva [23] have been reported in the literature. The protein content of the soups and stew in this study is higher than those reported for five native soups consumed by the Nupe tribe of Niger State of Nigeria [24].

The increase in fat contents in the soups compared to the dried chips is believed to be due to addition of palm oil and other ingredients used in the soup preparation. Similar observation was recorded in other soup and sauce preparations [22, 23]. However, the values obtained for fat content of the soups in this study are lower compared with the values reported for the five native soups consumed by the Nupe tribe of Nigeria [24], though higher amount of palm oil was used for two soups in this present study. This may have resulted from the different ingredients used in preparation of soups in the two studies. The ash content in the dry chips and prepared soups and stew increased compared with the fresh sample due to reduction in moisture content as well as the contribution from the ingredients being added. The same trend was noticed in the literature [19, 22, 23, 25]. However, there was reduction in carbohydrate content of the soups compared with the dry chips. This was believed to be due to water absorption from soaking of the chips, and added water during cooking of the soups. The observed decrease is similar to the findings of Mepba *et al.*, [25] who recorded an increase in the carbohydrate content of fresh *Lycopersicon esculentum* in the dried form, and reduction in value when cooked. Over all, the soups had improved macronutrients compared with the fresh fruit sample.

Mineral composition of Fresh Fruit and Soups

The fresh Pawpaw fruit sample was very low in all the minerals studied. Its sodium, potassium, calcium, magnesium, phosphorus, iron, copper, zinc and manganese contents were similar to the values reported in the literature [2], with slight variations which could be due to geographic and climatic differences. However, sun drying the Pawpaw to chips led to highly significant increase in values of all the minerals. This observation is similar to the findings of Akubor and Ike [19], Mepba *et al.*, [25]; and Usman and Lockett [26].

Soaking of the dried chips in water and addition of water to the soups and stew during cooking led to significant decrease in mineral contents of the soups compared with the dry chips. This trend was also observed by Tunde-Akintunde [27] who reported loss in some minerals after rehydrating sun-dried bell pepper, and attributed the loss to leaching of the minerals into the water used for rehydration. Usman and Lockett [26] also noticed an increase in the mineral content of vegetables after sun-drying, and slight decrease in their values after cooking. The decrease was attributed to loss of the minerals in soaking water which was thrown away after rehydrating the vegetables, and further losses during cooking. To retain more of the mineral content of dried samples, hence, the need to use the rehydrating water in cooking the sample was recommended by

them so as to retain the leached minerals in the water [28]. Overall, the result shows that the soups are good source of minerals, especially sodium, potassium, calcium, magnesium, phosphorus, iron and zinc.

Vitamin composition of Fresh Fruit and Soups

The beta carotene, ascorbic acid and α-tocopherol content of the fresh fruit qualify it as a good source of antioxidants. The loss in vitamin C content during drying is similar to the findings of Mepba *et al.*, [25] who reported loss in vitamin C content in sun-dried water leaf and tomatoes; and Ndawula *et al.*, [29] who also reported loss in vitamin C and some B-vitamin content of sun-dried mango fruits, and attributed the losses to the fact that they are heat labile and were lost due to the heat of the sun. However, the increase in the vitamin content of the soups was due to the added ingredients, thus, the soups are good source of antioxidant vitamins.

Antinutrient Composition and Papain Content of Fruit and Soups

Due to negligible amount of antinutrients present in the fresh fruit, it is safe for consumption without any interference with other nutrients from other food sources. However, sun drying significantly increased some of the antinutrients (though still negligible) but reduced the papain content of the dry chips. The antinutrients were reduced in the soups compared with the dry sample, especially their papain content. The low antinutrient content of all the samples supports the findings of Aravind *et al.*, [2] who reported that the extract of the unripe fruit may contain little alkaloids, flavonoids, saponins and glycosides. Onibon *et al.*, [30] also reported low antinutrients in some Nigerian fruits including Pawpaw, and concluded that the low level of antinutrients in the fruits allows one to eat them raw with little or no processing. Their further reduction in the soups as compared to the dry chips was due to the action of heat from cooking. The reduction in papain content of the soups was believed to be due to the fact that heat denatured the enzyme.

Sensory Evaluation of Soups

Egusi soup was the most acceptable among the three soups, followed by Tomato stew. This was in line with the findings of Adepoju and Daboh [23] in which *Amaranthus hybridus* cooked with either *Egusi*, or *Egusi* with *Cirina forda* were more acceptable than plain vegetable soup. The three soups were generally acceptable and rated high by the panelists. *Egusi* and *Poucho* soups were rated higher than the Tomato stew in most of the parameters considered. In terms of aroma there was no significant difference among the soups.

Conclusion

Fresh unripe Pawpaw was high in moisture content, beta carotene, ascorbic acid and α-tocopherol, but very low in crude protein, fat, carbohydrates, gross energy, minerals and B-vitamins content. Sun drying resulted in increase in nutrient content of the chips except B-vitamins and vitamin C. The soups were good source of β-carotene, vitamins C and E, sodium, potassium, calcium, magnesium, phosphorous, iron and zinc. Soaking in water and discarding the drained water resulted in reduction in the mineral content of the soups when compared with the dry chips. The action of heat from cooking led to reduction in the antinutrient as well as papain content of the soups and stew. The oil added to the soups improved the colour and β-carotene content of the soups, without any significant difference in their aroma and texture. *Egusi* soup was most acceptable in terms of general acceptability. All the soups were nutrient-dense and relished by the panelists, and hence, are recommended to be consumed at all times to be able to meet greater part of micronutrient requirements of consumers.

Recommendation

Regular consumption of the soups and stew should be encouraged, as this will promote dietary diversity, nutrient intake and antioxidant status of consumers; thereby promoting good health, longevity and well-being of consumers.

Conflict of Interest

The Authors declare that there is no conflict of interest, as the research was self-sponsored.

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