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Comparative study on the nutritive composition of pawpaw *(Carioca Papaya)* and black plum (*Syzygium Cumini*) seed flours

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Abstract

This study investigated the chemical, minerals and nutritional composition of Pawpaw *(C. Papaya)* and black plum (*S. Cumini*) seed flours. The proximate composition was evaluated according to AOA C. The *C. Papaya* and *S. Cumini* seed flours were found to have moisture contents of 7.333±1.155, 6.666±2.309, Ash, 5.593±0.095, 5.717±0.126 Protein, 24.600±0.100, 22.36±0.493, Fat, 30.000±2.600, 26.233±0.451, Crude fibre 0.312±0.002, 0.031±0.001 and carbohydrates 32.590±1.155, 39.167±1.40%. Carbohydrates were the major nutrients found in C.Papaya 32.590±1.155% and S.*Cumini* seed 39.167±1.40. The minor components were crude fibre for both flours. The mineral composition was K, 0.022±0.001, 0.090±0.010, Ca, 0.046±0.006, 0.089±0.011, Zn, 0.078±0.002, 1.198±0.005, Fe, 0.435±0.325, 0.090±0.010, P, 0.116±0001, 0.067±0.007, 0.787±0.001, Mg, 2.322±0.077, 0.093±0.005 and Cu, 0.127±0.0255, 0.076±0.010 for *C. Papaya* and *S. Cumini* seed. *C. Papaya* seed contained a higher amount of Fe, P, Mg and Cu than *S. Cumini* seed .*S. cumin* seed flour was found to have a considerable amount of K, Zn and Ca than *C, Papaya* seed .The Amino acid profile for *C.Papaya* and *S.Cumini* were: Threonine, 1.134±0.002, 0.138±0.002, Histidine, 0.157±0.002, 0.257±0.002, Leucine, 0.416±0.002, 0.476±0.002, Isoleucine, 0.541±0.001, 0.641±0.001, Arginine, 0.887±0.001, 0.787±0.001, Methionine, 862±0.001, 0.181±0.001, Tryptophan, 0.013±0.001, 0.313±0.001, Tyrosine, 0.013±0.001, 1.113±0.001 and Aspartic acid, 0.731±0.002, 0.422±0.002 etc. Methionine was the most abundant acid in *C. Papaya*, while tyrosine was found in *S. cumin* seed. The least abundant acids were tryptophan and threonine for *C. Papaya* and *S. Cumini* seed. This suggested that the flour might serve as a rich source of essential protein. The flours possessed good functional properties and could serve as additives in baby food.

Keywords: proximate composition, amino acid, vitamins content, minerals, functional properties

Introduction

Global food security and economic advancement now rely solely on a decreasing number of plant species. In human history, several thousands of plant species have been regularly: used for food, fibre, shelter, industrial, cultural, and medicinal purposes Makanjunjuola (2018).

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However, only a few plants are widely used, while the remaining plant diversity is underutilised. Underutilised plants contribute significantly to family food security and serve as a means of survival during a drought, famine, shocks, and risks Assefa *et al.* (2019). They can also supplement nutritional requirements due to their high nutritional value. Due to the alarming increase in human population and depletion of natural resources, it has become imperative to explore the possibility of using new plant resources with great potential for food, fodder, energy, and industrial purposes.

Many underutilised plant species are nutritionally rich and adapted to low-input agriculture. The drastic reduction of these species can have an immediate adverse effect on rural dwellers' nutritional status and food security. The enhancement of underutilised plants can improve our diet and fight hidden hunger. For example, many underutilised fruits and vegetables contain more vitamin C and pro-vitamin A than widely available commercial species and varieties. The use of plants has long been an intimate part of local cultures and traditions. Many neglected and underutilised plant species play crucial roles in preserving cultural diversity associated with food habits, health practices, religious rituals, and social exchanges. Attention to neglected and underutilised plant species is an effective way to help a diverse and healthy diet and combat micronutrient deficiencies, the so-called 'hidden hunger' and other dietary deficiencies, particularly among the villagers and the vulnerable social groups in developing countries. Local communities have used these plant species for generations, but the current loss of local knowledge means their traditional uses are being forgotten. Many underutilised plant species can contribute immensely to a better diet for local communities.

Pawpaw *(Carica Papaya)* is a member of the *Caricaceae* family. It is a widely grown perennial tropical tree and an important fruit cultivated throughout the tropical and sub-tropical regions of the world. Papaya is a short-lived, fast-growing, woody, large, perennial herb with self-supporting stems up to 10 m in height. Papaya grows typically as a single-stemmed plant but may become multi-stemmed when damaged. Ripe Papaya is consumed as a fruit. At an un-ripe stage, the fruit is consumed as a cooked vegetable, used as an ingredient in Papaya salad and cooked dished, according to Makanjunjuola (2018). *Papaya* seed has contributed to numerous health effects, and its skin possesses various wound-healing properties. The seed and skin pulp contain various phytochemicals, including natural phenol and flavonoids, which have antioxidant properties. They also contain thiamine, niacin, and riboflavin. Dilas *et al*. (2009) reported that the agro-industrial by-product is a good source of bioactive compounds, and exploitation of these in large quantities might be useful in pharmaceutical and food processing and are sources of minerals, fibres and phenolic compounds that have anti-viral, anti-bacteria and cardioprotective properties. Several studies have evaluated the medicinal potential of different parts of the *Papaya* plant, such as leaves, shoots, roots, and latex. According to Adeneye *et al.* (2009), two tablespoons of pulverised *Papaya* seed mixed with hot water twice dailyis helpful in managing diabetes and obesity.

Black–plum (*Syzygium Cumini*), a family of *Verbanaceae*, is a tree crop that grows in open woodland and savannah regions of tropical Africa. It is the commonest of the *Vitex* species in West Africa. It produces fruits which are plum-like, sweet and edible. The matured fruit is green and changes to dark brown when entirely ripped, with the pulp surrounding a hard stone containing 1 – 4 seeds. It is a savannah species and can, therefore, be found in northern, eastern, and western Nigeria. Adejumo *et al.* (2013).

The tree's stem bark extract is used to control hypertension and its anti-hepatotoxic effect and treatment of stomach aches, pains, disorders, and indigestion. Ladeji *et al.* (2005) extracted and analysed the bark of *Syzygium Cumini* and found it to contain much more potassium and phosphate than calcium, magnesium, zinc, and iron.

Carica Papaya (pawpaw) and *Syzygium Cumini* (black plum) are underutilised seeds, mostly considered environmental waste. Their nutritional benefits have been overlooked; therefore, this study aims to provide information on the nutrient composition of *Carica Papaya* (pawpaw) and *Syzygium Cumini* (black plum) seed flours, which might encourage their incorporation into the diet.

Materials and Methods

Collection of Samples and Geographical Location

Black plum and Pawpaw seeds were obtained from Adeleke University (7° 43' 59.99" N) and Orisunbare market (7.7821° N, 4.5487°}in Ede south and Olorunda Local Government area of Osun State, Nigeria, respectively. The seed samples were obtained after peeling their exocarp and endocarp. The seed samples were sun-dried, ground into fine powder and stored in an air-tight container before analysis. All the reagents used are analytical grade, and the apparatus used was obtained from the chemistry laboratory at Adeleke University.

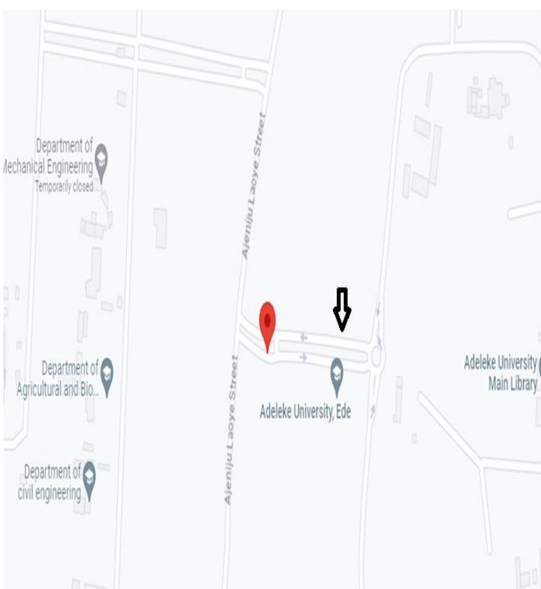

Fig 1. Adeleke University campus

Moisture Content

5 g each of the seed flour was weighed into the dish and oven-dried at 105˚C for 3 hours. It was cooled in a desiccator and reweighed. The moisture content was calculated as the percentage of the original sample weight.

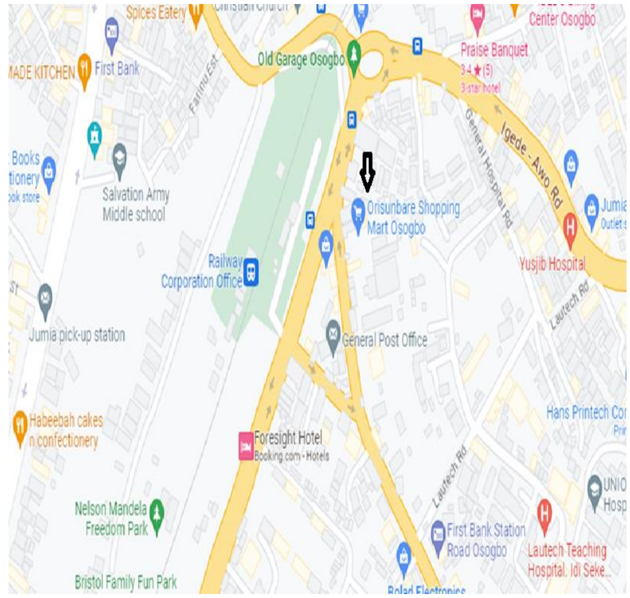

Fig 2. Orisumibare Market, Olorunda

Fig.3. *Carica Papaya* seed

Fig 4. *CaricaPapaya* seed flour.

Fig.5. *Syzygium Cumini* seed

Fig. 6. *Syzygium Cumini* seed flour

% moisture content= $\frac{W2-W3}{W2-W1} \times 100$

where W_1 =weight of the empty evaporating dish
W_2 weight of sample + evaporating dish

W_3 = weight of sample + evaporating dish after drying at 105˚C

Ash Content

About 2.0 g of each seed flour was weighed into an ignited ash dish, cooled in a desiccator, and weighed soon after reaching room temperature. It was ignited in a muffle furnace at 550˚C for 6 hours. The dish was cooled in a desiccator and weighed soon after reaching room temperature. The procedure was repeated for the remaining samples, and the total ash was calculated as the percentage of the original sample weight, as shown below:

$$\% \text{ Ash} = \frac{W3 - W1}{W3 - W1} \times 100$$

where;
W_1 =weight of empty crucible
W_2= weight of sample + crucible
W_3 = weight of sample + crucible after ashing at 550˚C

Protein Content

About 2 g each of the seed flour was weighed into a digestion tube, and 15 mL of concentrated H_2SO_4 was added to dissolve the sample. Kjeldahl tablets were added to start the digestion process in a fume cupboard pre-set at 410˚C for 45 minutes until it gave a clear solution before adding 75 mL of distilled water to prevent it from solidifying after digestion. The tube was placed in a distilling unit, and 50 mL of 40% NaOH was dispensed into the diluted solution and the digested distillate into 25 ml of 40% boric acid for 5 minutes. The distillate was titrated against 0.47MHCl until the first grey colour appeared. A blank was first run, and the titre value was recorded in line with AOAC (2015). The percentage of nitrogen is a product of total nitrogen and the conversion factor.

The percentage protein is calculated as follows:

$$\text{Vs} = \frac{\text{V}_h \text{ x}.01401\text{x N acid } (6.25)}{\text{The original wt of the sample used}} \text{ x } 100$$

Where Vs = Vol (ml) of acid required to titrate the sample

V_b = Vol (ml) of acid required to titrate blank,

N = normality of acid.

Crude Fibre Content

The crude fibre was determined using the method of AOAC (2015). About 2 g each of flour was weighed into a 600 mL long beaker. About 200 mL of hot 1.25% H_2SO_4 was added. The beaker was placed on the digestion apparatus with preheated plates, boiled, refluxed for 30 mins, and filtered through Whiteman GFA paper by gravity.

The beaker was rinsed with distilled water. The residue was washed on the paper with distilled water until the filtrate was neutral. The residue was transferred from the paper to the beaker containing 200 mL of hot 1.25% NaOH. Again, the samples were boiled for 30 mins and washed as before with hot water. The paper with residue was transferred into a crucible, dried at 100˚C overnight, cooled in a desiccator and reweighed (weight A). The residue was put into a furnace set at 600˚C for 6 hours, cooled in a desiccator and reweighed (weight B). The loss in weight during incineration represents the weight of crude fibre.

Fat Content

10 g each of flour (W_1) was weighed and put into a test tube. 10 ml of conc. HCl was added and put in a boiling water bath until solid particles dissolved and the mixture became brown. It was taken off and cooled, then transferred into a separating funnel.10 mL of ethanol and 30 mL of diethyl ether were added and shaken, leaving the solution to stand and separate. A clean, dried conical flask (W_1) was weighed, and the ether layer was taken into the conical flask. The extraction was repeated twice with 25 mL of diethyl ether, and the solvent was evaporated in a water bath. The fat at 105 ˚C in an oven was Cooled and weighed (W_2). The procedure was repeated for the remaining samples, and the % fat was calculated as shown below:

Ether extracts (100g) dry matter = (weight of extracted lipids/ weight of dry sample) x100

Carbohydrate

Carbohydrate analysis was obtained by difference, i.e. (100% - crude protein, crude fat, ash, crude fibre, and moisture level of the flour samples).

Mineral Determination

The mineral composition of the seed flours was done using the standard analytical method AOAC (2005). One (1) g of sample was digested with nitric/perchloric/sulphuric acid mixture in the ratio 9:2:1, respectively, and filtered. The filtrate was made up to mark in a 5mL volumetric flask. The filtered solution was loaded onto an Atomic Absorption Spectrophotometer (model 703; Perkin Elmes, Norwalk, CT). The standard curve for each mineral, calcium, magnesium, iron, aluminium, lead, copper, and zinc, was prepared from known standards. The mineral value of samples was estimated against that of the standard curve. Values of sodium and potassium were determined using a Flame photometer (Sherwood Flame Photometer 410; Sherwood Scientific Ltd., Cambridge, U.K.) using Nail and KCl as the standard (AOAC, 2005), while phosphorus was determined using the Vanodo-molybdate method.

Determination of Amino Acid Profile

Pawpaw and Black plum seed flour hydrolysates were prepared following the method of Moore *et al.* (1958). Each defatted sample was weighed (200 mg) into a glass ampoule, 5 mL of 6 mol/L. HCl was added, and the contents were hydrolysed in an oven preset at 105.5 °C for 22 h. Oxygen was expelled in the ampoule by passing nitrogen gas into it. Amino acid analysis was done by ion-exchange chromatography using a Technicon Sequential Multisampling Amino Acid Analyzer (Technicon Instruments Corporation, New York, NY). The analysis period was 76 min, with a gas flow rate of 0.50 mL/min at 60 °C, and the reproducibility was 3%. The amino acid composition was calculated from the areas of standards obtained from the integrator and expressed as percentages of the total protein.

Determination of Vitamins A, C and E

Determination of Vitamin A

Vitamin A content was determined by the method described in the Marck index (2001). 2g of seed flour was weighed into a flat bottom flask, and 10 mL of distilled water was added to the sample. 25 mL of 0.5 M alcoholic KOH solution was then added. The mixture was heated in a water bath for 1 hour and cooled before adding 30 mL. The hydrolysates obtained were transferred into a separatory funnel. The solution was extracted three times with 250 mL of chloroform. 2g of Anhydrous Na_2SO_4 was added to the extract to remove any trace of water. The mixture was then filtered into a 100 ml volumetric flask and made up to mark with chloroform. A standard solution of Vitamin A range of 0 – 50 μg/ml was prepared by dissolving 0.003 g of standard Vitamin A in 100 ml of chloroform. Absorbances of the sample and standards were read on the Spectrophotometer (Metrohm Spectronic 21D Models) at a wavelength of 328 nm, and vitamin A content was calculated as shown below:

Vitamin A in µg/100g = Absorbance of sample * Gradient factor× Dilution factor

Vitamin C Determination

Vitamin C content was determined using the method described by Onwuka (2005). 5 g of seed flour was homogenised in 45 ml of distilled water. The suspension was then filtered. An aliquot (5 ml) of the filtrate was measured into a 250 ml conical flask, and 0.1 ml of glacial acetic acid was added. Dichlorophenol indophenols were titrated.

Vitamin E Determination

Vitamin E content was determined by the method described in the Marck index (2001). One (1) g of seed flour was weighed, and 10ml of methanol was added. The sample was homogenised and filtered. 0.4 ml of the extract was taken, and 7.6 ml of colour developer (containing sodium dihydrogen phosphate (0.84 g), Ammonium molybdate 1.24 g, 8.15 ml H_2SO_4 and 250 ml methanol were added to the sample. A known volume (0.4 ml) of methanol was added to the sample. The sample was incubated at 900 ^oC for 1 hour. The absorbance of the sample was read at 695nm using a Spectronic 21D spectrophotometer. The concentration of vitamin E was extrapolated from the standard curve that was prepared.

Determination of Functional Properties

Water Absorption Capacity

This was determined using the method of Ekpereka *et al.* (2020) and Ikpeme-Emmanuel *et al.* (2009). One (1) g of each seed flour was dispensed into a weighed centrifuge tube with 10 ml of distilled water and mixed thoroughly. The mixture was allowed to stand for 1 hour before being centrifuged at 3500 rpm for 30 minutes. The excess water (unabsorbed) was decanted, and the tube inverted over an adsorbent paper to drain dry. The difference determined the weight of water absorbed. The water absorption capacity was calculated as:

WAC=water absorption index was calculated as follows:

$$\text{WAC (\%)} = \frac{\text{weight gain upon hydration}}{100}$$

Oil Absorption Capacity

The oil absorption capacity was performed in line with the method described by Ekpereka *et al.* (2020). To 1 g each of the flour, 10 ml of refined corn oil was added in a weighed 50 ml centrifuge tube agitated on a vortex mixer for 2 min and centrifuged at 4000 rpm for 20 min. The volume of free oil was recorded and discarded. The tube was weighed with the content. Oil absorption capacity was expressed as ml of oil bound by 100 g dry flour.

$$\text{Oil Aborption Capacity(\%)} = \frac{\text{Y} - \text{X}}{\text{X}}$$

where Y= Final weight of sample and tube

X=initial weight of sample and tube

Bulk Density

Bulk density was determined by the method described by Onwuka (2010). A10 mL capacity graduated measuring cylinder was filled gently with each sample. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level.

$$\text{Bulk density} = \frac{\text{weight difference}}{\text{Initial volume}}$$

Foaming Capacity

About 2 g of each seed flour was blended with 100 mL distilled water in a Kenwood blender. The suspension was whipped in an ace homogeniser (NSEIAM-6) at 1600 rpm for 5 min. The mixture was poured into a 250 mL graduated cylinder and the volume was recorded after 30 sec. The foaming capacity was expressed as a percentage increase in volume using the formula:

$$\text{Foaming Capacity (\%)} = \frac{\text{volume after whipping} - \text{volume before whipping}}{\text{Volume before whipping}}$$

Emulsion capacity

5 mL portions of protein solution (10 mg/mL) were homogenized with 5 mL oil using a Var whirl mixer for 1 min. The emulsions were centrifuged at 11006g for 5 min. The height of the emulsified layer and that of the total contents in he tube were measured

$$\text{Foam stability (\%)} = \frac{\text{Foam Volume after time t}}{\text{initial foam volume}} \text{x } 100$$

Results and Discussions

The moisture content in pawpaw (7.333±1.155) was higher than black plum seed flour (6.666±2.309). At a 95% confidence level, there was a significant difference (p <0.05) in the moisture contents of pawpaw and black plum seed flours. The values reported in this study were higher than *Treculia Africana* seed flour 4.890% Okpaegbe *et al.* (2021) and lower than the 11.00% reported for African nutmeg seed flour Adegbite *et al.* (2021). The moisture content of the flours studied fell within the acceptable range of (0%–10%). This indicated that seed flours can be stored long without degradation Agomuo *et al.* (2011). Ash refers to the inorganic residue remaining after ignition or complete oxidation of organic matter in a food sample. The ash contents reported in this study were pawpaw seed flour (5.593 ± 0.095) and black plum seed flour (5.717± 0.126). These values were higher than *Treculia Africana* seed flour (1.980%) reported by Okpaegbe *et al.* (2021). The values obtained were higher than the recommended value of 1.5-2.5 % for suitability as animal feed. This implied that these seed flours might be useless in formulating animal feeds. At 95% confidence level, there was no significant difference (p>0.05) in ash content between the seed flours. Fibre diets promote the wave-like contraction that moves food through the intestine. High-fibre food expands the inside walls of the colon, easing the passage of waste, thus making it an effective anti-constipation. It also lowers cholesterol levels in the blood, reduces the risk of various cancers and bowel diseases, and improves general health and well-being. The crude fibre content of seed flours was (0.031±0.002) for pawpaw and (0.031± 0.001) for black plum. These values were lower than *Treculia Africana* seed flour (5.610%) reported by Okpaegbe *et al*. (2021). At 95% confidence level, there was no significant difference (p > 0.05) in the fibre content of both flours. The low crude fibre suggested that the seed flours might not likely prevent constipation. It has been reported that crude protein serves as an enzymatic catalyst, mediates cell response, sand controls growth and cell differentiation (Whitney & Rolfes, 2005). The protein content of the pawpaw seed flour, 24.600±0.100, was higher than 22.367±0.493 for black plums respectively. The values in this study were higher when compared with 16.30 % and 6.02% reported for watermelon and pawpaw seed flours Olorode *et al.* (2014) and agreed closely with 21.15 ± 0.08 reported for fermented moringa seed flour Ijarotimi *et al.* (2013}. The high protein content of the seed flours could serve as protein supplements for cereals and other plant foods in Nigeria. The fat content in pawpaw seed (30.000± 2.600) was slightly higher than black plum seed flour (26.233±0.451). These values were significantly higher than *Tequila Africana* seed flour (8.510%) reported by Okpaegbe *et al.* (2021). The high amount of oil reported in this study suggested its usefulness for commercial purposes. The carbohydrate content in pawpaw seed flour was 32.590 ±1.155 and 39.167 ±1.401 for black plum seed flour. These values were significantly lower than the African star apple kernel at 52.00% Akubor *et al.* (2013). The black plum seed flour was higher when compared with the pawpaw seed flour. This implied that the seed flours can be used in carbohydrate-deficient diets as a source of daily energy requirements.

Minerals Composition Results

Table 2 presents the mineral composition of pawpaw and black plum seed flours. Minerals are essential for growth and reproduction and involve many digestive, physiological, and biosynthetic processes within the body Talukdar *et al.* (2016). Magnesium contents of 2.322±0.077 mg/100 g were the most abundant mineral in pawpaw seed flour, while Potassium content of 0.022 ±0.001 mg/100 g was the least abundant mineral.

Table 1: Proximate Analysis of Pawpaw ad Black Plum Seed

Nutritional component	Pawpaw seed	Black plum seed
Moisture content (%)	7.333±1.155[a]	6.666± 2.309[b]
Ash content (%)	5.593±0.095[b]	5.717±0.126[b]
Protein content (%)	24.600±0.100[a]	22.367±0.493[b]
Fat content (%)	30.000±2.600[a]	26.233±0.451[b]
Crude fibre (%)	0.312±0.002[a]	0.031±0.001[b]
Carbohydrate (%)	32.590±1.155[a]	39.167 ±1.401[b]

Note: Values show means of triplicate analysis ± standard deviation. At a95% confidence level ($p < 0.05$), figures with different superscripts along the row significantly different

In black plum seed flour, a Zinc content of 1.198 ±0.005 mg/100 g was found to be the most abundant mineral, while a Phosphorous content of0.067±0.007mg/100g was the least abundant mineral. Calcium is responsible for the building as well as maintenance of bones and teeth, essential for blood clotting and required in nerve transmission. Calcium content in pawpaw and black plum seed flour was 0.046 ±0.006 mg/100 g and 0.089 ±0.011 mg/100 g, respectively. At 95% confidence level, there was a significant difference ($p < 0.05$) in calcium content in both flours. However, these values were lower when compared with watermelon at 5.30mg/100g and pear seed at 5.01 mg/100 g Olorode*et al. (*2014). The low content of calcium reported in this study suggested that both seed flours might not be suitable as additives in calcium-deficient diets for maintaining strong bones and teeth. Potassium helps in regulating acid-base equilibrium and osmotic pressure of body fluids. The potassium content in pawpaw seed flour and black plum flour were 0.022 ±0.001 mg/100 g and 0.090 ±0.010 mg/100 g, respectively. These values were significantly lower when compared with raw moringa seed 26.33 ± 0.33 mg/100 g and fermented moringa seed flour 25.13±0.09 mg/100 g Ijarotimi*et al*. (2013). At a 95% confidence level, there was no significant difference ($p > 0.05$) in the potassium content of pawpaw and black plum seed flours. Iron is essential for forming haemoglobin, oxygen transportation and increased resistance to infection. It also functions as part of enzymes involved in tissue respiration. The iron content in pawpaw seed flour and black plum flour was 0.062±0.325 mg/100 g and 0.090±0.010 mg/100 g, respectively. These values were lower when compared with 1.04 ±0.00 mg/100 g. The low iron content reported in this study was less than the daily requirement of 7.00 mg/100g for men and 12.0-16.0 mg/100g for pregnant women, thus indicating that both seeds might not be useful in treating anaemia patients. At a 95% confidence level, there was a significant difference ($p < 0.05$) in the amount of iron in both flours. Magnesium is found in bones and is needed for muscle contraction. The amount of magnesium in pawpaw 2.322 ± 0.077 mg/100 g was higher than black plum seed flour 0.093 ±0.005 mg/100 g. These values were considerably lower than watermelon seed flour 1608.67 mg/100 g Gwana *et al.* (2014). At 95% confidence level, there was a significant difference ($p < 0.05$) in the amount of magnesium in both flours. The magnesium content reported in this study suggested that pawpaw seed flour might be useful in magnesium-deficient nutrition for strong bone and teeth formation. The Phosphorus contents in this study were pawpaw seed flour 0.116 ±0.001 mg/100 g and 0.067±0.007 mg/100 g for black plum seed flour, respectively. At a 95% confidence level, there was a significant difference ($p < 0.05$) in the amount of Phosphorus content in both flours. The values obtained in this study were significantly lower than 483.23±0.030 mg/100g reported for *N, Sativa* seed flour Adeleke *et al.* (2021). The zinc content in pawpaw seed flour and black plum flour were (0.078±0.002 mg/100 g) and 1.198 ±0.005 mg/100 g, respectively. At 95% confidence level, there was a significant difference ($p < 0.05$) in the zinc content of Pawpaw and Black plum seed flours. The values reported in this study were lower when compared with 3.24 ±0.000 mg/100 g for sour soup seed flour Onyechi *et al.* (2014). The zinc content reported in this study suggested that black plum seed flour can be used as a supplement in Zn-deficient diets and weaning food formulations.

The amino acid content of the seed flour is shown in Table 4. The results revealed that Pawpaw seed contained 18 amino acids: 9 essential amino acids such as threonine, Histidine, Leucine, isoleucine, Arginine, Methionine, lysine, cysteine, Valine, and phenylalanine and 8 non-essential amino acids namely; Proline, Serine, Alanine, cysteine, tyrosine, tryptophan, Aspartic acid and glutamic acid. Black plum seed contains15 amino acids: 8 essential amino acids such as threonine, Histidine, Leucine, isoleucine, Arginine, Methionine, lysine, and phenylalanine and 6 non-essential amino acids namely serine, Alanine, tyrosine, tryptophan Aspartic acid and glutamic acid. The total content of glutamic acid and Aspartic % obtained in this study for pawpaw 2.217% and Black plum seed flour 1.408% was lower than 29.5% reported for melon, pumpkin and gourd seed Adeyeye (2004).

The results of amino acid in seed flours were significantly lower when compared with sandbox seed flour reported by Olatidoye *et al.* (2010) and Aremu *et al.* (2006). At a 95% confidence level, there was a significant difference ($p < 0.05$) in the amino acid content of Pawpaw and Black plum seed flours. The most abundant essential amino acid in pawpaw seed flour was Methionine 1.862±0.001, while Arginine, 0.787±0.001, was found in Black plum seed flour. Therefore, this suggested that the consumption of both seed flours could play crucial roles in children's growth when used as additives in weaning food. The most abundant non-essential amino acid found in pawpaw seed was glutamic Acid, 1.486±0.001, while tyrosine, 1.113±0.001, was the most abundant non-essential amino acid in black plum seed. The least abundant amino acid in the seed flours was tryptophan 0.013±0.001 for pawpaw seed and Threonine 0.138±0.002 for black plum seed flour. However, Valine, Proline, and cysteine were not found in black plum seed flour.

Table 2: Mineral composition (mg/100 g) in Pawpaw seed and Black plum seed

Minerals	Pawpaw seed	Black plum seed
Potassium (K)	$0.022±0.001^{a}$	$0.090±0.010^{a}$
Iron (Fe)	$0.435±0.325^{a}$	$0.090±0.010^{b}$
Phosphorus(P)	$0.116±0.001^{a}$	$0.067±0.007^{b}$
Calcium (Ca)	$0.046±0.006^{a}$	$0.089±0.011^{b}$
Magnesium (Mg)	$2.322±0.077^{a}$	$0.093±0.005^{b}$
Copper (Cu)	$0.127±0.0255^{a}$	$0.076±0.010^{b}$
Zinc (Zn)	$0.078±0.002^{a}$	$1.198 ±0.005^{b}$

Note: Values show means of triplicate analysis ± standard deviation. At a 95% confidence level ($p < 0.05$), figures with different superscripts along the row are significantly different.

Table 3: Amino acids of Pawpaw and Black plum seed

Amino acids	Pawpaw seed	Black plum seed
	ESSENTIAL AMINO ACIDS	
Threonine	1.134±0.002[a]	0.138±0.002[b]
Histidine	0.157±0.002[b]	0.257±0.002[b]
Leucine	0.416±0.002[a]	0.476±0.002[a`]
Isoleucine	0.541± 0.001[n]	0.641±0.001[b]
Arginine	0.887±0.001[a]	0.787±0.00[b]
Methionine	1.862±0.001[a]	0.181±0.001[b]
Phenylalanine	0.284±0.002[a]	0.314±0.002[b]
Lysine	0.149±0.001[a]	0.206±0.007[b]
Valine	0.184±0.002	Nil
	NON-ESSENTIAL AMINO ACIDS	
Proline	0.295±0.001	Nil
Cysteine	0.073±0.003	Nil
Alanine	0.251±0.002[a]	0.235±0.002[b]
Glycine	1.234±0.002 [a]	0.240±0.002[b]
Tryptophan	0.013±0.001[a]	0.313±0.001[b]
Tyrosine	0.113±0.001[a]	1.113±0.001[b]
Glutamic Acid	1.486±0.001[a]	0.986±0.001[b]
Serine	0.442±0.011[a]	0.316±0.005[b]
Aspartic acid	0.731±0.002[a]	0.422±0.002[b]

Note; Values show means of triplicate analysis ± standard deviation. At a 95% confidence level ($p < 0.05$), figures with different superscripts along the row are significantly different

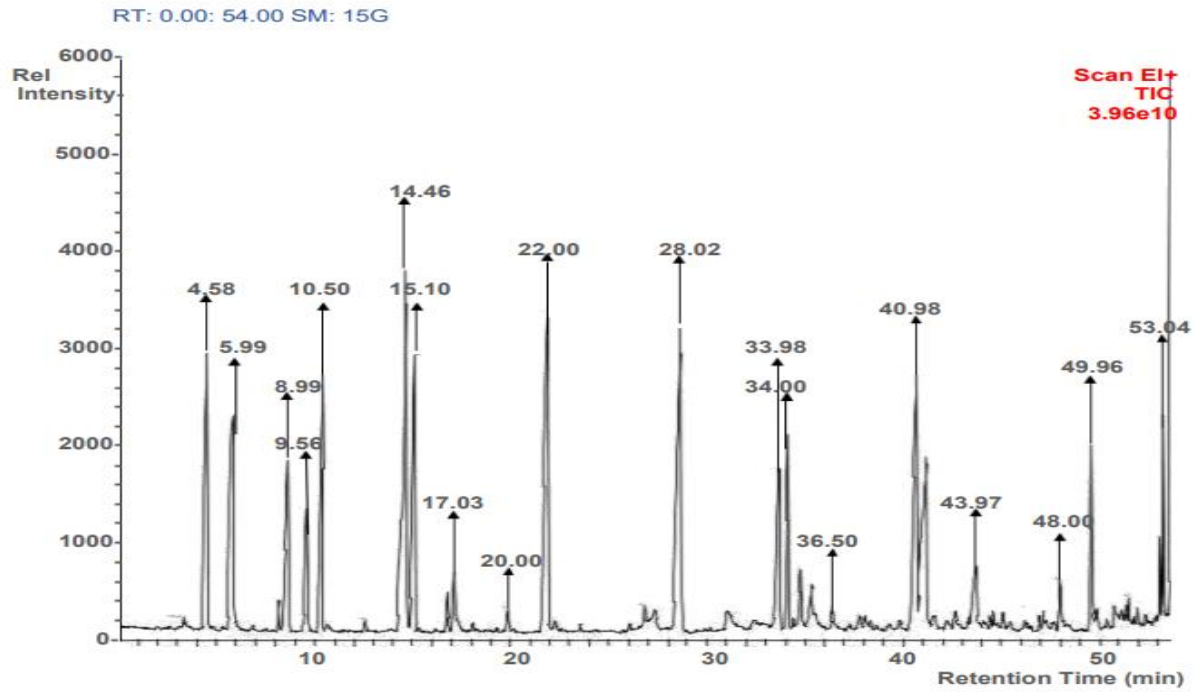

Figure7: Chromatography showing the ion concentration and the RT of the amino acids present in Pawpaw seed.

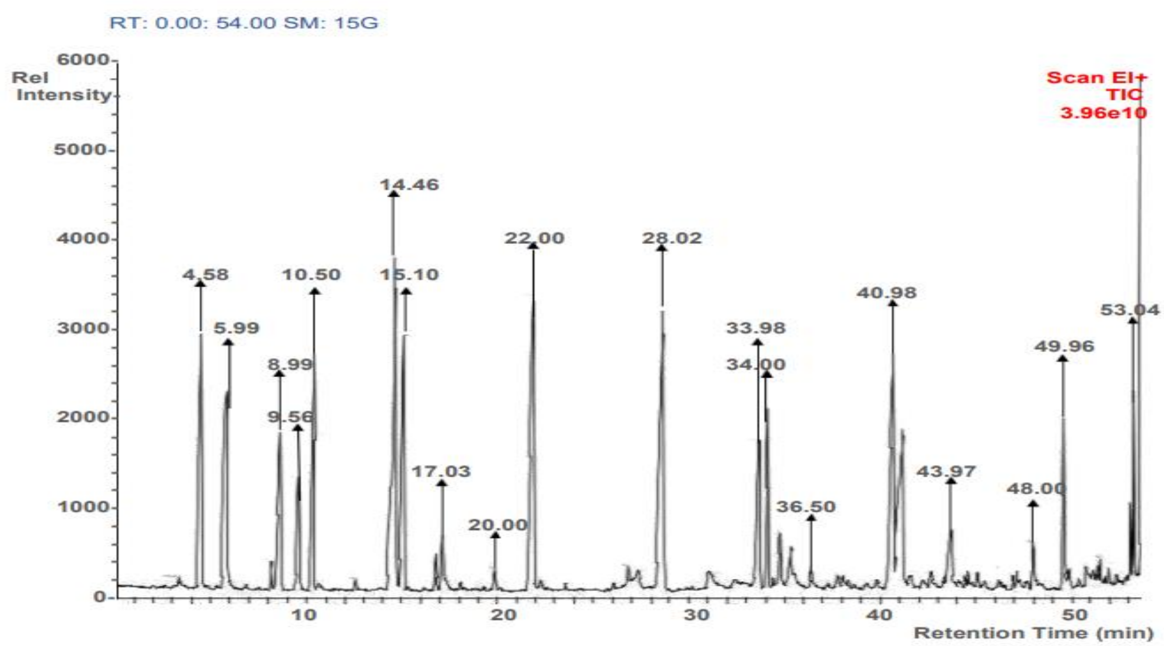

Figure 8: Chromatography showing the ion concentration and the RT of the amino acids present in Black plum seed

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Vitamins can be defined as essential nutrients needed by the body to function properly. They play several roles in many processes, such as growth, digestion and immunity. The result of the vitamin content of black plum and pawpaw seed flours was presented in Table 4 in mg/100 g. Both pawpaw seed 8.964±0.131 and black plum seed 12.655±0.083 were significantly higher in Vitamin C compared with 0.90 ± 0.09 reported for soursop seed flour, Onyechi *et al.* (2014). Vitamin E in pawpaw seed 0.591 ±0.010 and black plum seed 0.507 ±0.009 were significantly lower compared to *Citrullus lanatus* seed 8.86 ±0.10 reported by Peters *et al.* (2022). At a 95% confidence level, there was no significant difference (p>0.05) in the amount of Vitamin C, E and Ain pawpaw and black plum seed flours. However, at a 95% confidence level, there was a significant difference (p < 0.05) in the amount of Vitamin C, E and A for both seed flours. Vitamin C and E are considered antioxidants, which play significant roles as scavengers in removing free radicals from the body, thus preventing the damage of cells and heart-related diseases. Vitamin A in pawpaw 6.030 ±0.075 and black plum 6.055 ±0.075 seed flour was higher than 3.873±0.34 reported for *Nigella sativa* seed flour Adeleke *et al.*(2023). Vitamin A plays a crucial role in the improvement of vision. This suggested that incorporating seed flour into diets will enhance vision and prevent the diseases associated with high blood pressure and diabetes. Table 5 presents the functional properties of the seed flours. Proteins and carbohydrates significantly influence food's water absorption capacity due to the presence of hydrophilic components like polar or charged side chains. Interestingly, flours that can absorb water well and swell for improved consistency in food (high water absorption capacity) have beneficial applications in dough, processed meats and custards.

The water absorption capacity of pawpaw seed flour was 1.107 ±0.129% close to black plum seed flour 1.093 ±0.034%. These values were significantly lower than 296.77 and 270 34 reported for watermelon and pear seed flours Olorode *et al.* (2014). The low water absorption capacity showed that a good weaning food could be produced with the seed flours. At 95% confidence level, there was no significant difference (p>0.05) in the amount of water absorption capacity in pawpaw and black plum seed flours. Oil absorption capacity indicates the mouth–feel, aroma level, shelf-stability of seed flour and availability of oil in the seed. The oil absorption capacity of the pawpaw seed flour was 1.122±0.862% was in close range with black plum seed at 1.172 ±0.293%. These values were significantly lower than 88.37 ±8.62 for okra seed flour by Ofori *et al.* (2020). This low content of oil absorption capacity indicated that the seed flours might not be good sources of oil for commercial purposes .At a 95% confidence level, there was no significant difference (p>0.05) in the amount of oil absorption capacity in pawpaw and black plum seed flours. Emulsion capacity indicates the presence of protein residue and emulsifying fat in the seed flours. The emulsion capacity of the pawpaw seed 357.141±0.861% was higher than black plum seed flour 262.217± 0.416%. At a 95% confidence level ,there was a significant difference (p < 0.05) in the amino acid content of Pawpaw and Black plum seed flours. The high emulsion capacity value reported in this study suggested that seed flours might be useful as protein supplements in the diet. Bulk density indicates the presence of carbohydrates in the seed flours. The bulk density of the seed flours was 0.360 ±0.038% and 0.340 ±0.305%, respectively. These values were lower than 0.80 ± 0.01 for dried Okra seed flour Ofori *et al*. (2020). At a 95% confidence level , there was no significant difference(p>0.05) in the amount of bulk density in pawpaw and black plum seed flours. The low bulk density is an advantage in the formulation of weaning food because it allows the caloric and nutrient intake per feed per child and satisfies their daily energy and nutrient requirements. The swelling capacity indicates high carbohydrate or starch content in seed flours. The swelling capacity of pawpaw seed flour 260±20.000% was lower than the 310 ±1.000% reported for black plum seed flour. However, the values were considerably higher than 105.71, 106.60, 104.90and 104.82 at

Table 4: Vitamins composition of pawpaw and black plum seed

Vitamins	Pawpaw seed	Black plum seed
Vitamin A	6.030±0.075[b]	6.055±0.075[b]
Vitamin C	8.964±0.131[a]	12.655±0.083[b`]
Vitamin E	0.591±0.010[a]	0.507±0.009[a]

Note: Values show means of triplicate analysis ± standard deviation. At a 95% confidence level ($p < 0.05$), figures with different superscripts along the row are significantly different.

Table 5: Protein functional properties of pawpaw and black plum seeds

Functional properties	Pawpaw seeds	Black plum seeds
Water absorption capacity	1.107 ±0.129[a]	1.093±0.034[a]
Oil absorption capacity	1.122±0.862[a]	1.172±0.293[a]
Emulsion capacity	357.141±0.861[c]	262.217± 0.416[b]
Foaming capacity	6.920 ±0.880[a]	0.000 ±0.000[a]
Bulk density	0.360±0.038[a]	0.340 ±0.305[a]
Swelling capacity	260±20.000[b]	310±1.000[b]

Note: Values show means of triplicate analysis ± standard deviation. At a 95% confidence level ($p < 0.05$), figures with different superscripts along the row are significantly different

65%, 75%, 85% and 95% reported for benoil seed oil Olorode *et al.* (2014). The high swelling capacity in the seed flour is an indication of high carbohydrate or starch content, which suggests that the seed flour could be a good source of energy for daily intake of food and very useful in dough and bread baking content, which suggests that the seed flour could be a good source of energy for daily intake of food and very useful in dough and bread baking.

Conclusion

This study showed that pawpaw and black plum seed flours contained appreciable amounts of proteins, fat, crude fibre, vitamins and minerals. The results of the functional property in this study showed that the seed flours could be used in infant food formulation. The results also revealed essential nutrients suitable for human consumption and food processing.

Conflict of Interest

The authors declared no conflict of interest

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