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Nutritional, Phytochemical, and Anti-Nutrient Profiling of *Parkia biglobosa* Fruit Pulp: Potential as a Micronutrient and Antioxidant Source

[1]*Afolabi, F., [2]Adedokun, A. A., [2]Adebayo, O. R., [2]Abiona, M. A. and [3]Afolabi, O.

[1]Department of Physical and Chemical Sciences, Federal University of Health Sciences, Ila-Orangun, Osun State, Nigeria.
[2]Department of Applied Sciences, Osun State Polytechnic, Iree, Osun State, Nigeria.
[3]Department of Science Laboratory Technology, Osun State Polytechnic, Iree, Osun State, Nigeria.

***Corresponding Author's Email:** fatai.afolabi@fuhsi.edu.ng

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Abstract

Qualitative determination of the phytochemical, mineral, and antinutrient composition of *Parkia biglobosa* fruit pulp, an underutilized fruit, was carried out. The results established that this fruit pulp is a nutrient-rich food with significant potential for improving dietary diversity and addressing nutritional deficiencies. It contains essential minerals such as potassium (28.61 mg/100g), iron (1.11 mg/100g), zinc (0.59 mg/100g), and copper (0.19 mg/100g), along with vitamin C (503 mg/100g), which supports physiological functions and helps prevent oxidative stress. The moderate presence of phytochemicals, including alkaloids, flavonoids, tannins, and saponins, contributes to its health benefits and potential therapeutic properties. Despite containing antinutrients such as oxalate, phytate, and trypsin inhibitors, their levels remain within safe limits, posing minimal risk to mineral bioavailability. Given its rich composition, *Parkia biglobosa* fruit pulp can be integrated into diets in various ways, such as incorporating it into porridges, smoothies, baked goods, or traditional dishes to enhance micronutrient intake. Its natural sweetness makes it a suitable alternative to refined sugars in food formulations, offering a healthier option for sweetening beverages and snacks. Additionally, its antioxidant properties support immune health, making it a valuable dietary supplement, particularly in regions where malnutrition is prevalent. In summary, the fruit pulp presents a natural, sustainable means of improving nutritional intake and overall well-being while mitigating the risks of micronutrient deficiencies.

Keywords: Antinutrient; Fruit Pulp, Mineral, *Parkia biglobosa,* Phytochemical

1.0 Introduction

Global population growth and economic challenges have led to widespread nutritional deficiencies and numerous health ailments (Lopes *et al.,* 2023). Fruits are essential components of human diets, addressing nutritional deficits as sources of monosaccharides, minerals, dietary fibers, biologically active compounds such as vitamin C, and natural antioxidants (Ioniță-Mîndrican *et al.,* 2022; Rejman *et al.,* 2021). *Parkia biglobosa* is a versatile and underutilized tree, commonly known as the African locust bean tree, with all its parts serving various nutritional, economic, ecological, and medicinal purposes. Native to West Africa, the fruit pulp of *P. biglobosa* is locally called 'igba'or 'iyere' in Yoruba land, Nigeria and is renowned for its high energy content, vitamins, minerals, and carbohydrate yield (Afolayan *et al.,* 2017; Asunni *et al.,* 2024). The acceptance and use of *P. biglobosa* is on the increase and forms an important part of health care in Nigeria and many other countries. Nutritionally, the seed has high protein content and it is used as a condiment in soup to enhance taste and flavor. The fruit pulp is good for its high energy value, vitamins, minerals and carbohydrate yielding (Afolayan *et al.,* 2017; Ayanrinde *et al.,* 2023).The leaves is high in fiber and can be used in formulation of ruminants diets or grazing animals and played a vital role in nutrition of livestock feed as emergency source of feed for ruminants(Afolayan *et al.,* 2017).Economically all its parts can generate income in one way or the other; provide a mean of trade to the people of its locality, both the raw and fermented seeds are sources of trade for women, the trees are used in plank making for houses, mortar and pestle, charcoal and firewood (Ayanrinde *et al.,* 2023; Fingesi, 2023). Ecologically the tree acts as erosion control, provide shade and houses for bees and birds, and controls wind.(Surya and Richard, 2022). Medicinally, the drink made from the pulp can promote good sight reduce hypertension and can also be used for treatments of diseases like stroke, diabetes, malaria, wounds, dysentery, rheumatism headache, pain, fungal infection, tonic, anti-diarrhea, female sterility, skin infection, sores ulcers, mumps antiemetics, severe colic, snake bites, toothache, burns, fever, hemorrhoids, constipation, anorexia, bronchitis, whooping cough, yellow fever, stomach ache, mouth ulcers, wasp and bee sting and pneumonia (Saleh *et al.,* 2021; Singha *et al.,* 2021). Many traditional medicine practitioners in Africa recommend the use of *P. biglobosa* leaves aqueous extracts to patients as treatment for various ailments including stroke diabetes and cancers because of the present of phenolic compound which are responsible for their anti-oxidant activities. Several bioactive compounds with protein binding properties against various ailments include flavonoids, polyphenols, saponins, tannins, terpenoids, xanthene's, quinonoid, steroids, and alkaloids. These bind to the toxic proteins of the causative agent, thereby inactivating them. (Komolafe *et al.,* 2024; Philip *et al.,* 2021). Several useful natural antioxidants, including vitamins, flavonoids, terpenoids, tannins, polyphenols, and some minerals like selenium from plants, are strong antioxidants in lipophilic and hydrophilic environments. They can also stabilize cell membranes, scavenge and eliminate oxygen free radicals, and function as immunomodulators.They work against oxidative damage due to phospholipase A2 activity by selectively binding to the active sites or modifying the conserved residues that are critical for the phospholipase A2 catalysis (Eboma *et al.,* 2020; Khan and Ilies, 2023). In vitro study of the properties of plant parts extracts used by indigenous people is an important approach towards discovering and developing traditional herbal medicines and showed comparable or in some cases greater antiprotozoal activity than modern drugs (Evbuomwan *et al.,* 2023). Despite its diverse applications and increasing use, limited research has focused on the comprehensive profiling of *P. biglobosa* fruit pulp, particularly its nutritional composition, phytochemicals, and anti-nutritional factors. Understanding the interplay between its beneficial compounds and potential anti-nutrients is essential to establish its safety and efficacy as a food source. Additionally, the presence of heavy metals such as lead in edible portions of plants raises safety concerns, underscoring the need for detailed analysis. While studies have highlighted the nutritional and medicinal significance of *P. biglobosa*, there is a lack of detailed investigations into the balance between its micronutrient content, phytochemicals, and anti-nutritional factors. Furthermore, the impact of anti-nutrients on its nutritional value and safety, especially concerning permissible limits, remains underexplored. This study aims to fill this gap by comprehensively determining the elemental composition, phytochemical profile, and anti-nutritional properties of *P. biglobosa* fruit pulp. Specifically, it seeks to assess its potential as a safe and valuable source of micronutrients and antioxidants while evaluating the impact of antinutrients and heavy metal contamination on its overall safety. The findings will contribute to a better understanding of its nutritional benefits, aiding in its broader acceptance and utilization in food and medicinal applications

2.0 Materials and Methods

2.1 Sample Collection and Treatment

The sample was collected from branches of locust bean trees at Igbolamu area, Obaagun, Ifelodun Local Government Area of Osun State, Nigeria. The plant was identified at the Biology Laboratory's herbarium unit by a botanist from the Department of Science Laboratory Technology at Osun State Polytechnic in Iree, Nigeria. The samples were washed with distilled water to remove sand and other unwanted particles. For four weeks, the sample was allowed to air dry. A grinding mill was then used to turn the dry sample into a fine composite powder. The fine powder was kept in an airtight container for further analysis.

2.2 Determination of Mineral Content

The minerals were determined after sample wet digestion with a mixture of $HNO_3/HCl_4O/H_2SO_4$ in the ratio 9:2:1 v/v, respectively (Hassan *et al.,* 2011). Fe, Cu, Zn, K and Pb were determined using Atomic Absorption Spectrophotometer (AAS) 236-12 model.

2.3 Qualitative Phytochemical Analysis

Test for Flavonoids: When a few drops of 20% sodium hydroxide were added to 2 ml of sample extract, a bright yellow coloration formed. The yellow color vanished when a few drops of 70% diluted hydrochloric acid were introduced. Flavonoids are present in the sample when a yellow color forms and then fades.

Test for Saponins: 6 ml of distilled water was added to 2 ml of sample extract, and the mixture was rapidly shaken: The presence of saponins is indicated by the production of bubbles or persistent foam.

Test for Tannins: When 10% alcoholic ferric chloride is added to 2 ml of sample extract, the production of a brownish blue or black color shows the presence of tannins.

Test for Alkaloids: 2 ml of each extract were combined with 1ml of Marquis reagent,2 ml of strong sulfuric acid, and a few drops of 40% formaldehyde. The presence of alkaloids is indicated by the emergence of a dark orange or purple color.

Determination of Vitamin C (Ascorbic acid)

10 ml of 4% oxalic acid and 5 ml of standard ascorbic acid (100µg/ml) were measured and added to a conical flask. A 0.0005M solution of 2,6-Dichlorophenol Indophenol Dye (DCPIP) was used to titrate the combination. At the endpoint, measurements were made of the pink color's presence and persistence for 15 seconds. The quantity of ascorbic acid consumed is equal to the quantity of color consumed. In a conical flask with 10 ml of 4% oxalic acid, 5 ml of the sample (made by taking 5 ml of the sample in 10 ml of oxalic acid) was measured and titrated against the dye. Equation 1 was used to determine the amount of ascorbic acid:

$$Ascorbic\ acid\ in\ mg/100g\ of\ sample = \frac{X-B}{E} - \frac{F\ X\ V}{Y}\ X100\ (1)$$

where X is the test blank titration's average volume in milliliters.
B is the test blank titration's average milliliter.
F = Mg ascorbic acid, which is the same as 1.0 ml of standard indophenol solution.
E = Sample weight
V is the initial test solution's volume.
Y = Titrated Volume of Test Solution

2.4 Anti-nutrients

Determination of Oxalate Content

Procedure: 2 g of the fruit pulp were filtered and adjusted to 200 ml following a half-hour boiling distilled water extraction process. However, the hot water extract residue was further extracted using 150 ml of boiling 1 M HCl for 30 minutes. This was then adjusted to 200 ml and filtered. The two filtrates were mixed together. The content of oxalate in the two fractions was analyzed based on the method of Andualem and Gessesse, (2014) with the help of potassium permanganate titration. All the analyses were tested and the results were calculated and expressed on a dry-weight basis.

Determination of Trypsin Inhibitor

Liener's (1979) approach was used to determine the samples' trypsin inhibitor activator. Weighing the sample into a screw-cap centrifuge tube yielded 0.2 g. After adding 10 ml of 0.1 M phosphate buffer, the mixture was agitated on a mechanical shaker for one hour at room temperature. The resulting suspension was filtered using Whatman No.1 filter paper after being centrifuged for five minutes at 500 rpm. Phosphate buffer was used to get the volume down to 2 ml. To act as a blank, 6 ml of a 5% tricarboxylic acid (TCA) solution was added to one of the test tubes, which were kept in a water bath at 37 oC. All of the tubes that had been previously stored at 37°C were filled with 2 ml of casein solution, and they were then incubated for 20 minutes. After 20 minutes, 6 ml of TCA solution was added to the experiment tubes, and the reaction was halted by shaking them. At room temperature, the reaction was permitted to continue for one hour. Whatman filter paper was used to filter the mixture, and at 250 nm, the absorbance of the filtrate from the sample and trypsin reference solutions were measured.

It can be calculated using equation 2

$$X = \frac{\text{Y x 94.44}}{0.22150} \quad (2)$$

Where X = concentration, Y absorbance

Determination of Phytate Content

The composition of the phytotic acid content was examined using Russel's (1980) methodology. 2 g of the sample were weighed into a 250 ml conical flask, 10 ml of 2% concentrated solution was added, and the mixture was filtered after three hours of soaking. 50 ml of the filtrate were then pipetted into a 250 ml beaker, and 100 ml of 0.3 percent ammonium thiocyanate solution was added as an indicator. The standard iron (ii) chloride solution, which contains 0.0195 g Fe/ml, was then titrated with a brownish yellow color that lasted for five minutes.

To calculate the phytate content: phytate g/kg = .0019 X Volume of $FeCl_3$ consumed X DF sample weight

DF: Total volume of extraction solvent added/ volume of aliquot taken for titration Note: DF = 3($\frac{150}{50}$)

3.0 Results and Discussions

The elemental composition of *Parkia biglobosa* fruit pulp, as presented in Table 1, provides valuable insights into its nutritional and safety profiles: the concentration of iron (1.108 ± 0.23 ppm) indicates the fruit pulp contains a moderate level of this essential micronutrient. Iron is crucial for hemoglobin synthesis and oxygen transport in the blood. The detected amount suggests the fruit pulp can contribute to addressing iron deficiency in diets, especially in populations prone to anemia. The iron content is lower than the levels reported in similar leguminous fruit pulps, such as *Tamarindus indica*, which contains 14.28–15.8 mg/100g (Akajiaku *et al.,* 2014; Kanfon *et al.,* 2023). But very close to the value of 2.011µg.g^{-1} reported for cowpeas by (Dakora and Belane, 2020), in nine genotypes planted at Taung South Africa. Zinc was present at 0.590 ± 0.03 ppm. This trace element is vital for immune system function, wound healing, and DNA synthesis. While the amount is relatively low, it still contributes to the overall micronutrient value of the pulp and may support daily zinc requirements when consumed in sufficient quantities. The zinc concentration was lower than 3.73 mg/100 g reported for Indian spinach by (Asaolu *et al.,* 2012). The zinc (Zn) concentrations found in this investigation are consistent with Mohammed and Sharif (2011). According to their findings, the highest concentration of zinc was found in *C. tridens* (0.375 mg/g), followed by *V. amyglidina* (0.318 mg/g). *H. canabinus, C. tora,* and *C. olitorius* had zinc concentrations of 0.250 mg/g, 0.228 mg/g, and 0.221 mg/g, respectively. The concentration of copper (0.189 ± 0.02 ppm) is within the acceptable range for dietary intake. Copper plays an essential role in enzymatic reactions, iron metabolism, and maintaining healthy connective tissues. This copper level is similar to that observed in *Adansonia digitata* (baobab) pulp, which contains 0.15–0.25 ppm (Osman, 2004). Notably, lead was not detected (ND) in the fruit pulp. This is a positive finding, as lead is a toxic heavy metal with severe health risks, including neurological damage, especially in children. The absence of lead makes the fruit pulp safer for consumption from a toxicological perspective. The absence of lead is consistent with the assertion that because locust bean seeds don't accumulate lead, they can be eaten without worrying about contracting food poisoning (Oluwamiyi and Bazambo, 2016). Potassium is the most abundant mineral in the fruit pulp, with a concentration of 28.610 ± 0.02 ppm. This high potassium content highlights the fruit pulp as a potential dietary source of this essential macronutrient, which is crucial for maintaining electrolyte balance, supporting heart health, and regulating muscle and nerve functions. The potassium content exceeds that of bananas, which typically contain 20–25 ppm (Wall, 2006). Overall, the elemental analysis establishes *Parkia biglobosa* fruit pulp as a safe and nutrient-rich food source with the potential to enhance dietary diversity and nutritional adequacy. The phytochemical composition of *Parkia biglobosa* fruit pulp, as presented in Table 2, provides valuable insights into its potential health benefits and therapeutic applications. The presence of key bioactive compounds, including tannins, alkaloids, saponins, and flavonoids, underscores its dual role as a functional food ingredient and a source of nutraceuticals. Tannins are moderately present in the fruit pulp. These polyphenolic compounds are widely recognized for their antioxidant, antimicrobial, and anti-inflammatory properties. By either increasing fecal nitrogen or decreasing protein bioavailability, they decrease the digestibility of proteins in both humans and animals. Tannins can cause enzymatic browning and astringency, which alter food's color and reduce its palatability. Additionally, they reduce the activity of lipase, chymotrypsin, and amylase, which hinders the absorption of iron and degrades the quality of proteins. (Singh *et al.,* 2023). Other physiological effects of tannins have also been documented, including the production of liver necrosis, the reduction of blood pressure, the acceleration of blood coagulation, the reduction of serum cholesterol levels, and the modulation of immunoresponses.

Table 1: Elemental composition of *Parkia biglobosa* fruit pulp

Parameters	Concentration (ppm)
Fe	1.108 ± 0.23
Zn	0.590 ± 0.03
Cu	0.189 ± 0.02
Pb	ND
K	28.610 ± 0.02

values are mean ± value standard deviation (SD) of triplicates, ND: not detected

Table 2: Phytochemical screening of *Parkia biglobosa* fruit pulp

Tannins	Alkaloids	Saponins	Flavonoids
+	++	+	+

Key: ++ highly present; + moderate present; - Absent

Table 3: Anti-nutrient composition of *Parkia biglobosa* fruit pulp

Parameters	Values (mg/100g)
Oxalate	0.0328 ± 0.02
Trypsin	23.880 ± 0.01
Phytate	0.066 ± 0.02

values are mean ± value standard deviation (SD) of triplicates

Table 4: Vitamin C content *Parkia biglobosa* fruit pulp

Component	Value (mg/100 g)
Vitamin C	5.3 ±0.02

Value mean ± value standard deviation (SD) of triplicates

For these actions, the kind and amount of tannins are crucial (Chung *et al.,* 1998). The moderate level of tannins observed in *Parkia biglobosa* pulp indicates a balanced contribution to its therapeutic benefits without posing significant anti-nutritional risks, aligning with findings in other tropical legumes such as *Tamarindus indica* (Nyaga *et al.,* 2023). The fruit pulp contains a high concentration of alkaloids, which are bioactive compounds with diverse pharmacological properties, including antimicrobial, analgesic, and anti-inflammatory activities. Alkaloids in high concentrations have been linked to traditional treatments for infections and inflammation (Heinrich *et al.,* 2021). This high presence in *Parkia biglobosa* pulp is comparable to that in *Moringa oleifera* leaves, which also show significant medicinal potential due to their alkaloid content (Ma *et al.,* 2020). Saponins are moderately present in the fruit pulp. These compounds are known for their cholesterol-lowering effects, immuneboosting properties, and potential as natural antioxidants (Osman, 2004). Additionally, saponins contribute to anti-cancer and anti-inflammatory activities. The moderate level observed in *Parkia biglobosa* pulp is consistent with levels found in *Adansonia digitata* (baobab), further supporting its functional and therapeutic potential (Wall, 2006). The moderate presence of flavonoids in *Parkia biglobosa* fruit pulp adds to its antioxidant properties. Flavonoids help combat oxidative stress, potentially reducing the risk of chronic diseases such as cardiovascular disorders and certain cancers (Kumar and Pandey, 2013). The level of flavonoids in *Parkia biglobosa* pulp is similar to that

reported for *Vigna unguiculata* (cowpea), a leguminous plant also rich in antioxidants (Udensi *et al.,* 2012). The anti-nutrient content of *Parkia biglobosa* fruit pulp, as presented in Table 3, indicates relatively low levels of oxalate (0.0328 ± 0.02 mg/100g), trypsin inhibitor (23.880 ± 0.01 mg/100g), and phytate (0.066 ± 0.02 mg/100g). These values are below the threshold considered harmful, aligning with findings from previous research, and demonstrate that the fruit pulp has minimal anti-nutritional implications. The oxalate content in the fruit pulp (0.0328 ± 0.02 mg/100g) is significantly below the lethal dose range of 200–500 mg/100g (Salgado et al., 2023). Oxalates, when present at high levels, bind divalent minerals such as calcium, thereby reducing their bioavailability and contributing to issues like kidney stones, gut irritation, and mineral deficiency (Salgado *et al.,* 2023). The low oxalate content in *Parkia biglobosa* ensures that these adverse effects are minimized. Furthermore, this value is consistent with earlier findings by Hassan *et al.* (2011), who reported low oxalate levels in *Parkia biglobosa*, confirming its safety for consumption regarding oxalate toxicity. The phytate content (0.066 ± 0.02 mg/100g) in this study is notably lower than the permissible limit of 22.1 mg/100g set by WHO (2003). Phytates, known for their mineral-chelating properties, can reduce the bioavailability of essential minerals like calcium, iron, and zinc by forming insoluble complexes (Castro-Alba *et al.,* 2019). However, the levels observed here are sufficiently low to avoid significant mineral absorption interference. This value compares favorably with earlier studies, such as 0.60 mg/100g reported for
Parkia biglobosa forage by Afolayan *et al.* (2017) and 0.634% for *Garcinia kola* by Dike and Nnamdi, (2012). In contrast, much higher phytate levels (8.47 mg/100g) were observed in *Pachycarpus bisacculatus* roots (Dodo *et al.,* 2024). Interestingly, phytates also offer health benefits, such as protecting against cardiovascular diseases and certain cancers (Pires *et al.,* 2023). Nevertheless, their strong chelation properties highlight a balance between beneficial and adverse effects, as they can compromise mineral bioavailability (Manzoor *et al.,* 2024). The trypsin inhibitor level in the fruit pulp (23.880 ± 0.01 mg/100g) is relatively low. Trypsin inhibitors interfere with protein digestion by inhibiting the activity of the enzyme trypsin, essential for protein breakdown. The low levels suggest that the fruit pulp's protein digestibility is unlikely to be significantly compromised. Overall, the antinutrient profile of *Parkia biglobosa* fruit pulp, characterized by low oxalate, phytate, and trypsin inhibitor levels, indicates its safety and suitability for consumption. These low levels align with permissible thresholds, minimizing the potential for mineral bioavailability interference or toxicological concerns. Additionally, the results underscore the nutritional and health-promoting potential of *Parkia biglobosa* fruit pulp, as its anti-nutritional factors are within acceptable limits. Table 4 presents the vitamin C content of *Parkia biglobosa* fruit pulp, measured at 5.3 ± 0.02 mg/100 g. This value reflects a modest concentration of ascorbic acid (vitamin C) in the fruit pulp, which is a critical micronutrient known for its health-promoting properties. Vitamin C is a potent antioxidant that plays essential roles in various biological functions, including: Enhancing the immune response and protecting against infections. Facilitating the formation of collagen, vital for skin health, wound healing, and the maintenance of connective tissues. It also promotes the absorption of non-heme iron, which is particularly important in preventing iron-deficiency anemia. Furthermore, it protects cells from oxidative damage by neutralizing free radicals, thereby reducing the risk of chronic diseases such as cardiovascular conditions and certain cancers. However, the vitamin C content in *Parkia biglobosa* fruit pulp (5.3 mg/100 g) is modest compared to other fruits and vegetables, such as oranges (53 mg/100 g), guava (228 mg/100 g), and tomatoes (23 mg/100 g). While the vitamin C concentration in *Parkia biglobosa* is relatively low, it still contributes to dietary intake, especially in regions where the fruit pulp is commonly consumed. Nontheless, the consumption of *Parkia biglobosa* fruit pulp can

help address vitamin C deficiencies, particularly in resource-limited settings where access to vitamin-rich fruits may be constrained. Its inclusion in traditional diets could complement other dietary sources to meet the recommended daily allowance (RDA) for vitamin C. The RDA for vitamin C varies by age and gender but is generally around 90 mg/day for adult men and 75 mg/day for adult women (FAO and World Health Organization, 1998).

4.0 Conclusion

The result of these findings establishes *Parkia biglobosa* fruit pulp as a nutrient-rich and safe food source with considerable potential to enhance dietary diversity and nutritional adequacy. Its phytochemical profile, rich in alkaloids and moderate levels of tannins, saponins, and flavonoids, underscores its dual role as a functional food ingredient and a potential source of bioactive compounds with therapeutic properties. The anti-nutrient analysis highlights low levels of oxalate, phytate, and trypsin inhibitors, ensuring minimal interference with mineral bioavailability and no toxicological risks, making it suitable for consumption. Furthermore, the presence of vitamin C, though modest compared to other fruits, adds to its nutritional value by supporting essential physiological functions and aiding in oxidative stress prevention. Overall, the nutritional and phytochemical composition of *Parkia biglobosa* fruit pulp reinforces its significance as a health-promoting dietary component. Incorporating it into daily diets, particularly in regions where it is widely available, can improve micronutrient intake and contribute to addressing nutritional deficiencies and promoting overall well-being.

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