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Research Article

Comparative study of the phytochemical, proximate and mineral constituents of the epicarp, mesocarp and seeds of processed African Mesquite (*Prosopis africana*)

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In Nigeria, numerous organic wastes from the processing of *Prosopis africana* are indiscriminately discarded and this has led to environmental pollution. This study compared the phytochemical, mineral and proximate constituents of epicarp, mesocarp and seeds of *P. africana*. Plant samples were collected from *P. africana* sellers in Ogodo, Ankpa Kogi State. The collected samples were dried at room temperature for 21 days and were grounded to a powdered form. Phytochemical, proximate and mineral analyses were carried out using standard methods of AOAC (2020). Data was analysed by One-way Analysis of Variance (ANOVA) at 95% confidence limits upper confidence limit and lower confidence limit using the SPSS, IBM Statistics version 21.0 software. Differences between groups were considered to be statistically significant at $p \leq 0.05$. Results revealed the epicarp, mesocarp and seeds of *P. africana* as a rich source of protein, carbohydrate and fibre and also contained considerable amounts of phytochemicals such as alkaloid, flavonoid, saponins, tannin and phenols. It also contained good composition of macro and micro elements like calcium, phosphorus, sodium, potassium, magnesium, zinc and iron. The seeds and epicarp contained a high nutritional and phytochemical composition compared to the mesocarp. The epicarp and mesocarp could be explored pharmacologically for their therapeutic values instead of being disposed.

Keywords: *phytochemical, mineral, proximate, Prosopis africana*

Introduction

Prosopis africana (African mesquite) is a leguminous evergreen tree belonging to the Fabaceae family (Alagbe, 2023). In Nigeria, the name varies from one ethnic group to the other. It is called ukpehie by the Igala people in the study area. Prosopis genera is made up of about 45 species and it thrives well in subtropical and tropical regions of the world including the Northern region of Nigeria (Alagbe, 2022). *P. africana* is the only species of Prosopis that originated in tropical Africa. The tree can grow up to 4-20m in height with a unique deep, fast-growing tap root. It majorly grows in the savanna vegetation of western Africa (Aduwamai et al., 2024). PA has diverse social, economic, cultural, medicinal and agricultural values. It is widely used and consumed in Nigeria and other countries of the world. It is vastly known for its seeds, a highly demanded condiment or seasoning that is rich in minerals, protein, fatty acids and other essential nutrients (Akpata et al., 2023). According to Alagbe et al. (2023), *P. africana* is one of the many underutilized medicinal plants due to its numerous endowments. The leaves, bark, stem and roots are good sources of phytochemicals like flavonoids, alkaloids, terpenoids, saponins, tannins and steroids which have been documented to increase growth rate, reduce feed retention time, enhance sweetness and pathogenic microorganisms in animals (John, 2024). However, the concentrations of these phytochemicals are dependent on the plant's age, processing methods as well as species' geographical locations (Alagbe, 2022). Fermented seeds of *P. africana* are used as spices to enhance the sweetness and flavor of foods. The pods can be used as fodder for cattle, sheep and goats (Alagbe, 2023). The medicinal values of Prosopis species have been mentioned in ancient literature (Akpata et al., 2023). An early report mentioned that all parts of *P. africana* are traditionally used by indigenous people for curing various ailments (Gangbe et al., 2022). The active chemicals in the leaves, roots and stems act as anti-inflammatory, antiviral, antibacterial, antioxidant and possess hepato-protective activities. The leaves, stem and bark are used traditionally to treat malaria, toothache, paralysis, piles, sexually transmitted infections, pimples and general body weakness. Also, the roots are used in the treatment of diarrhea, headache, cough, cold and visceral obstructions (Orish et al., 2024). The epicarp of PA is the outer thick membrane covering the mesocarp and the seeds. The mesocarp is the milky or sometimes whitish structure found immediately after the epicarp while the seed is the edible portion of the plant. Both the epicarp and mesocarp are discarded after processing. The seeds of *P. africana* contain some volatile phenolic compounds and essential oils which can be used for the treatment of bronchitis, paralysis, aphrodisiac, poisonous bites from snakes, and leprosy (Eschen et al., 2023). Fermented seeds of *P. africana* are very useful and are widely consumed as condiments but the pulp and epicarp are disposed as wastes. Despite the huge importance, high consumption rate and the potential use of PA as a source of income in Ogodo, Ankpa Kogi State. The rural dwellers process *P. africana* without the practice of waste management.

To date, there is no literature report on the epicarp and mesocarp of *P. africana*. Also, there is no documented study on *P. africana* in the study area. Information on similarities and differences in plant parts is needed for the proper use of plant genetic resources. Hence, it is necessary to evaluate the phytochemical, mineral and proximate composition of the seed and waste products (epicarp and mesocarp) from *P. africana* for any possible bioactive constituents.

Materials and Methods

Collection of plant samples

Epicarp, mesocarp and seeds of *P. africana* were collected from *P. africana* sellers in the study area. The collected samples were dried under room temperature to prevent microbial growth and also to reduce the pungent smell. The dried sample was ground into powder with the aid of pestle and mortar and was used for the mineral, phytochemical and proximate analyses.

Extraction method

Ethanolic extraction was carried out using standard methods of AOAC (2010). 50 g of each of the powdered samples was dissolved in 100 mL of ethanol and proceeded by extraction through percolation. Thereafter, the mixture was concentrated in a rotary vacuum evaporator, dissolved in water, and used for the study. The percentage yield was calculated relative to the starting material.

$$\text{Yield (\%)} = \frac{\text{Weight of extract (g)}}{\text{Weight of pulverized leaves (g)}} \times 100 \qquad \text{equation……….1}$$

Quantitative Phytochemical screening

Alkaloid, phenol, tannin, saponins and flavonoid, were determined using standard methods of AOAC (2020).

Evaluation of the Mineral Composition

Phosphorous, calcium, magnesium, potassium, manganese, sodium, iron and zinc were determined using absorption spectrometry according to Dhellot et al. (2006) and Tatiya et al. (2007).

Proximate analysis

Moisture, carbohydrates, fibre, protein, lipids and ash contents were analyzed according to standard methods of AOAC (2010).

Data Analysis

The results were subjected to One-way Analysis of Variance (ANOVA) using version 21.0 software. The data was expressed as mean ±standard deviation and the difference between groups was considered as statistically significant at $p \leq 0.05$.

Results

Proximate composition of epicarp, mesocarp and seeds of *Prosopis africana*

The proximate results of the epicarp, mesocarp and seeds of *Prosopis africana* are shown in Table 1 ($P<0.05$). A significant difference was noticed in the moisture, ash, crude fibre, protein, lipid and carbohydrate contents. The seed recorded the highest moisture content (8.55 ± 0.22^a), then epicarp (7.13 ± 0.11^b) and then mesocarp (4.43 ± 0.37^c). Similarly, the seed also recorded the highest ash content (23.10 ± 0.48^a), then epicarp (18.27 ± 0.10^b) and then mesocarp (9.11 ± 0.58^c). Similar trends occurred in the seed with the highest record of crude fibre content (8.11 ± 0.74^a), then the epicarp (6.22 ± 0.73^b) and then the mesocarp (4.18 ± 0.93^c). The highest record of crude protein was also noticed in the seeds (38.39 ± 0.64^a), then epicarp (20.36 ± 0.16^b) and then mesocarp (16.38 ± 0.94^c). However, the highest lipid content was recorded in the epicarp (4.38 ± 0.88^a) followed by the seeds (2.65 ± 0.73^b) and mesocarp (1.37 ± 0.22^c). Finally, the highest carbohydrate content was recorded in the seeds (42.77 ± 0.42^a), followed by epicarp (28.63 ± 0.19^b) and mesocarp (14.85 ± 0.08^c).

Table 1. Proximate composition of epicarp, mesocarp and seeds of *Prosopis africana*

Parameter	Epicarp	Mesocarp	Seeds
Moisture %	7.13 ± 0.11^b	4.43 ± 0.37^c	8.55 ± 0.22^a
Ash %	18.27 ± 0.10^b	9.11 ± 0.58^c	23.10 ± 0.48^a
Crude fibre %	6.22 ± 0.73^b	4.18 ± 0.93^c	8.11 ± 0.74^a
Protein %	20.36 ± 0.16^b	16.38 ± 0.94^c	38.39 ± 0.64^a
Lipid %	4.38 ± 0.88^a	1.37 ± 0.22^c	2.65 ± 0.73^b
Carbohydrate %	28.63 ± 0.19^b	14.85 ± 0.08^c	42.77 ± 0.42^a

Means with the different alphabets as superscripts across rows differed significantly at $P\leq0.05$, SD, n= 3

Mineral evaluation of epicarp, mesocarp and seeds of *Prosopis africana*

The results of the mineral evaluation of epicarp, mesocarp and seeds of *Prosopis africana* are shown in Table 2. ($P<0.05$). Potassium, calcium, sodium, magnesium, iron, zinc and phosphorous contents differed significantly in the epicarp, mesocarp and seeds. Epicarp recorded the highest Ca (12.58 ± 0.73^a), followed by seeds (8.84 ± 0.10^b) and mesocarp (4.20 ± 0.33^c). Similarly, epicarp recorded the highest Mg (8.73 ± 0.29^a), followed by mesocarp (5.20 ± 0.85^b) and seeds (2.82 ± 0.18^c). More so, epicarp recorded the highest K (8.00 ± 0.21^a), followed by seeds (6.84 ± 0.18^b) and mesocarp (4.69 ± 0.73^c). However, seeds recorded the highest Na (12.33 ± 0.94^a), followed by epicarp (6.27 ± 0.73^b) and mesocarp (4.28 ± 0.67^c). Also, seeds recorded the highest Fe (2.80 ± 0.21^a), followed by epicarp (1.65 ± 0.08^b) and mesocarp (0.94 ± 0.02^c). In the same manner, seeds recorded the highest P (6.37 ± 0.88^a), followed by epicarp (3.43 ± 0.49^b) and mesocarp (2.11 ± 0.57^c). Finally, the highest Zn was cited in the mesocarp (5.00 ± 0.36^a), followed by epicarp (4.10 ± 0.99^b) and seeds (2.10 ± 0.11^c).

Table 2. Mineral evaluation of epicarp, mesocarp and seeds of *Prosopis africana* (Mg/100g)

Parameter	Epicarp	Mesocarp	Seeds
Calcium	12.58 ± 0.73^a	4.20 ± 0.33^c	8.84 ± 0.10^b
Magnesium	8.73 ± 0.29^a	5.20 ± 0.85^b	2.82 ± 0.18^c
Potassium	8.00 ± 0.21^a	4.69 ± 0.73^c	6.84 ± 0.18^b
Sodium	6.27 ± 0.73^b	4.28 ± 0.67^c	12.33 ± 0.94^a
Iron	1.65 ± 0.08^b	0.94 ± 0.02^c	2.80 ± 0.21^a
Phosphorus	3.43 ± 0.49^b	2.11 ± 0.57^c	6.37 ± 0.88^a
Zinc	4.10 ± 0.99^b	5.00 ± 0.36^a	2.10 ± 0.11^c

Means with the different alphabets as superscripts across rows differed significantly at $P\leq0.05$, SD, n= 3

Phytochemical composition of epicarp, mesocarp and seeds of *Prosopis africana* (Mg/100g)

Table 3 presents the phytochemical composition of epicarp, mesocarp and seeds of *P. africana* (Mg/100g) ($P<0.05$). The phytochemical constituents varied significantly in the epicarp, mesocarp and seeds of *Prosopis africana.* The highest alkaloid was recorded in the epicarp (9.75 ± 0.33^{a}), followed by the seeds (7.40 ± 0.47^{b}) and mesocarp (4.29 ± 0.05^{c}). Also, the highest flavonoid was cited in the seed (27.33 ± 0.19^{a}), followed by epicarp (17.81 ± 0.77^{b}) and mesocarp (10.26 ± 0.11^{c}). Similarly, the highest saponin was cited in the seed (11.57 ± 0.18^{a}), followed by epicarp (7.70 ± 0.42^{b}) and mesocarp (4.00 ± 0.27^{c}). More so, the highest tannin was cited in the epicarp (22.08 ± 0.79^{a}), followed by the seeds (18.82 ± 0.39^{b}) and mesocarp (8.04 ± 0.06^{c}). Finally, the highest phenol was shown in the seed (10.50 ± 0.82^{a}), followed by epicarp (6.52 ± 0.43^{b}) and mesocarp (2.74 ± 0.06^{c}).

Table 3. Phytochemical composition of epicarp, mesocarp and seeds of *Prosopis africana* (Mg/100g)

Parameter	Epicarp	Mesocarp	Seeds
Alkaloid	9.75 ± 0.33^{a}	4.29 ± 0.05^{c}	7.40 ± 0.47^{b}
Flavonoid	17.81 ± 0.77^{b}	10.26 ± 0.11^{c}	27.33 ± 0.19^{a}
Saponin	7.70 ± 0.42^{b}	4.00 ± 0.27^{c}	11.57 ± 0.18^{a}
Tannin	22.08 ± 0.79^{a}	8.04 ± 0.06^{c}	18.82 ± 0.39^{b}
Phenol	6.52 ± 0.43^{b}	2.74 ± 0.06^{c}	10.50 ± 0.82^{a}

Means with the different alphabets as superscripts differed significantly across rows at $P\leq0.05$, SD, n= 3

Discussion

The percentage moisture content of *P. africana* seed was found to be low. The values of moisture content in the present study are similar to earlier reports of Akpata et al. (2023) for *Prosopis africana*. The value revealed that the moisture content was lower since it is below the 15% maximum limit described by regulatory bodies for the resistance and growth of microorganisms. This implies that the epicarp, mesocarp and seeds can be preserved without deterioration hence extending shelf life. The ash content of *P. africana* seed was found to be highest in the seeds. The ash content of a plant material is a measure of its inorganic matter content. The value, however, is lower compared with the result of Akpata et al. (2023) for *Prosopis africana.* The percentage of crude protein of *P. africana* seed, epicarp and mesocarp was high compared with the crude protein of *P. africana* reported by Alagbe et al. (2023). Therefore, it can be used as an alternative source of protein in diets. The result of the percentage of crude fat in this study is lower compared to that of Alagbe *et al.* (2023). Fats are known to help the intestine in absorbing and transporting fat-soluble vitamins such as A, D, E and K (Agubosi et al., 2022). The lower value is an indication that *P. africana* seeds, mesocarp and epicarp could be a better fat product for people that could be vulnerable to disease conditions like obesity. The crude fibre content in this study was found to be higher compared to that of groundnut and pigeon pea. This indicates that it may aid digestion, and absorption of water from the body. High fibre content prevents constipation by softening and formatting bulky stools. The consumption of higher fibre food helps minimize some common health problems. The values obtained compared favourably with those of John (2024) in *Prosopis africana*. The high carbohydrate content of the seeds and epicarp of *P. africana* indicates that they will provide more energy to the body when supplemented to the diets of humans and livestock (Momoh et al., 2024). The result of phytochemical analysis indicates that the epicarp, mesocarp and seeds of *P. africana* are rich in alkaloids. The results of alkaloids in this study compare favourably with that of Akpata *et al*. (2023). Alkaloids are used as anesthetics and as Central Nervous System stimulants (Momoh et al., 2024). The result of flavonoid in this study is higher than that of Kolapo et al. (2023) on *Prosopis juliflora*. Flavonoids have high pharmacological and biochemical properties including radical scavenging properties (Alagbe et al., 2022). Saponin was observed to be higher in the seeds compared to the epicarp and mesocarp of *P. africana.* High percentages of saponins in food have been reported to induce a bitter taste hence reducing the palatability of the food or even imbuing animals with life-threatening toxicity (Lalitha et al., 2022). The consumption of a high concentration of saponin may be deleterious. This implies that *P. africana* seeds need to be properly processed to eliminate the high content of saponin before they can be consumed. Studies have shown that saponin could be beneficial to the body if consumed in the right quantity. For example, a concentration of 1 mg/100g in the diet of rats decreases plasma cholesterol and increases bile acid production (Momoh et al., 2024). The results of tannin in this study are highest in the epicarp followed by the seeds and mesocarp. This result is at variance with that of Kolapo et al. (2023) on seeds of *P. africana*. Tannins are known to have some medicinal value especially in the prevention of diarrhea, dysentery and controlled hemorrhage (Adeiza et al., 2023). The phenolic content in this study recorded the highest content in the seeds. This result coincides with that of Alagbe et al. (2023) on *P. africana*. A significant difference was observed in the sodium, iron, phosphorous, calcium, magnesium, potassium and zinc contents of the epicarp, mesocarp and seeds of *P. africana*. Among the elements, calcium and sodium were observed to be the highest while iron was the lowest. The values obtained from the analyzed sample were slightly above those reported by John (2024). This indicates that the epicarp, mesocarp and seeds are good sources of both macro and microelements. These macro and microelements are essential to the body for the normal metabolic and proper well-being of humans. Iron is a major constituent of haemoglobin (Momoh et al., 2024) while sodium functions in the maintenance of body fluid and tissues (Fasoyiro et al., 2023). Zinc functions in the maintenance of cellular membrane structures (Okafor et al., 2023). Copper is responsible for the release of iron from the cells into the plasma and it also functions in the energy metabolism of the body (Okafor et al., 2023). Zinc functions in the stimulation of the immune system (Momoh et al., 2024). Calcium helps in the growth of bone and teeth (Anaduaka et al., 2022). Magnesium aids circulatory activities in the body (Alagbe, 2023).

Conclusion

This study unveiled the seed, epicarp and mesocarp of *P. africana* to be a good source of protein, carbohydrate, and fibre and also contained considerable amounts of phytochemicals such as alkaloid, flavonoid, saponins, tannin and phenols. It contained a good composition of macro and micro elements like phosphorus, magnesium, sodium, zinc, iron calcium and potassium needed for normal growth and body development. The seeds and epicarp contained a high nutritional and phytochemical composition compared to the mesocarp. The epicarp and mesocarp could be explored pharmacologically for their therapeutic values in the production of drugs, antibiotics and plant metabolites.

These results unveiled the rich mineral, phytochemical and proximate contents of the seed, epicarp and mesocarp of *P. africana*. Multiple clinical studies should be conducted particularly on the epicarp and mesocarp to clearly emphasize and support their toxicity on internal organs.

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Author contributions

Momoh Theophilus Boniface, Okpanachi Clifford and Edogbanya Promise Ramallan Ocholi carried out the laboratory work. Hassan, Abdulrahman Ocholi and Okpanachi Maji Ojodumine wrote the manuscript. Okpanachi Grace Moriolake and Eladonye Blessing sourced for the plant samples and analyzed the data.

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Competing Interests

The author declares no conflict of interest. The manuscript has not been submitted for publication in other journal.

AI Tool Declaration

The authors declare that no AI and related tools are used to write the scientific content of this manuscript.

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