Comparative study on proximate, phytochemicals and mineral components of different parts of *Parkia biglobosa* (pod, seed, and leaf)

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Abstract- — A study was conducted to assess the proximate composition, phytochemicals, and mineral components of the pod, leaf, and seed of the *Parkia biglobosa* (*P. biglobosa*) tree, with the aim of determining their suitability as animal feed resources. The findings revealed that the seed exhibited significantly higher ($P < 0.05$) levels of crude protein (CP) and ether extract (EE) compared to the leaf and pod. Specifically, the seed recorded the highest values ($P < 0.05$) for CP (15.31±0.03) and EE (13.23±0.04), while the pod displayed the lowest values of 3.91±0.12 and 0.89±0.04 for CP and EE, respectively. The pod registered the highest values ($P < 0.05$) for crude fiber (CF) and nitrogen-free extract (NFE) with respective values of 8.85±0.1 and 75.14±0.11. Conversely, the leaf exhibited the highest ($P < 0.05$) ash content, while the seed had the lowest ash value (1.99±0.04). In the mineral analysis, the seed and pod had the highest values ($P < 0.05$) for calcium (Ca) and phosphorus (P), respectively. Phytochemical screening results indicated that the pod contained the highest values ($P < 0.05$) of alkaloid (19.06±0.09) and tannin (10.97±0.08), while the leaf showed the highest values ($P < 0.05$) for saponin (34.20±0.25) and hydrocyanic acid (HCN) (2.22±0.30). The overall conclusion drawn from this study suggests that all three parts of *P. biglobosa* (seed, pod, and leaf) have the potential to serve as alternative feed resources for livestock.

Index Terms- Alternative feed resources; anti-nutrients; Feed; Food security; minerals; proximate values; Sustainability

I. Introduction

The exponential growth of the global population is anticipated to result in food insecurity becoming a significant challenge in this century. Despite a steady decline in cereal production worldwide, projections suggest that the world's population will double in the next 50 years [1]. Magdoff and Tokar [2] reported that 36 million people currently suffer from food insecurity and hunger. This predicament may be attributed to diminishing agricultural output in developing nations, escalating food prices, and an increased use of grains for biofuel production. Addressing these challenges and achieving food security necessitates a revolutionary strategy in the agriculture sector. These issues also contribute to the scarcity of resources for livestock feed production, posing a particular challenge in the poultry sector where feed constitutes approximately 70 percent of the total production cost. Similar to humans requiring quality food for optimal health, poultry birds also depend on high-quality feed to convert consumed feed into essential products such as muscle, organs, skin, feathers, bones, and eggs. For efficient body metabolism and quality output, they also require minerals like calcium, phosphorus, salt, chlorine, potassium, sulfur, iron, copper, cobalt, as well as vitamins and antibiotics [3].

The competition between humans and livestock for diminishing conventional ingredients like maize and soybeans, coupled with the increased production of biofuels from cereals, has prompted research into alternative feed sources. This includes the exploration of farm wastes and other feeding materials that are not readily consumed by humans but can be processed and utilized as nutrition for livestock, addressing the challenge of feed-food competition [4].

Parkia biglobosa (*P. biglobosa*), also known as the African locust bean tree, belongs to the Fabaceae family. This evergreen tree, reaching heights of 20 to 30 meters, is found between 5° N and 15° N, spanning various African countries. It is a versatile legume tree traditionally used for food and medicinal purposes and holds significant commercial value in West Africa. The plant contains carbohydrates, proteins, fats, minerals, vitamins, tannins, and flavonoids.

The fruit of *P. biglobosa* is a slightly curved, brown indehiscent pod measuring 30 to 40 cm in length and 2 to 3 cm in width, containing up to 20 seeds. The seeds constitute 22% of the fruit, while the pod case makes up 42%, and the pulp accounts for 36%. The leaves are alternate, dark green, and bipinnate. The seeds, fruit pulp, and leaves are utilized in preparing various foods and drinks. The seeds are used in the preparation of iru, a protein- and fat-rich food. The yellow starchy pulp surrounding the seed is a valuable food supplement rich in Vitamin C and carbohydrates [5].

Parkia species are employed across tropical countries for medicinal purposes. Virtually all parts of Parkia plants are traditionally used to address different ailments [6]. In traditional medicine, P. biglobosa has been reported to be effective against diarrhea, dysentery and diabetes [7]. Various parts of the tree, including stem barks, leaves, pods, and roots, are applied in paste and decoction forms to treat skin-related diseases such as eczema, skin ulcers, measles, leprosy, wounds, dermatitis, chickenpox, scabies, and ringworm [8], [9]. Additionally, [10] noted that decoctions and pastes of the stem bark, pod, or root of *P. biglobosa* are used to treat hypertension, while the stem barks and leaves are employed for severe cough and bronchitis. Modupe [5] also highlighted the antimalarial, antihelminthic, antibacterial, antivenom, antidiabetic, antihypertensive, and antioxidant properties of the *Parkia biglobosa* tree.

The objective of this study is to compare the nutritive values of the three parts (seed, pod, and leaf) of the P. biglobosa tree and assess their potential as alternative feed resources for livestock.

II. MATERIALS AND METHODS

A. Research location

The experimental research took place at the Teaching and Research farms, Landmark university (8.1239 N, 5.0834 E), temperatures 16.67ºC to 33.33ºC Omu-Aran, Kwara state Nigeria for the period of ten weeks. The proximate analysis, antinutritional factors determination and mineral composition of the samples were determined in Animal Science Laboratory of the Institution.

B. Sources and preparation of the samples

The leaves and the pods of *P. biglobosa* were collected from Landmark University's community. Fresh leaves and pods (containing the seeds) were harvested from the trees of *P. biglobosa.* The leaves were air-dried, and ground into fine powder. The seeds were taken out from the pods, thereafter both samples were air- dried and grounded into powder.

C. Proximate analysis of samples

The proximate analysis was carried out by using the procedure of AOAC method [11]. Moisture content was determine by heating 2.0 g of each sample to a constant weight in a crucible placed in an oven maintained at 105 ºC. For ash determination, 2.0 g of the sample was incinerated in a muffle furnace at 550 ºC for 4 hours; ether extract (EE) content was obtained by thoroughly extracting 2.0 g of the sample in a soxhlet apparatus using n-hexane as the extractant. Crude fiber (CF) was obtained by digesting 2.0 g of sample with H_2SO4 and NaOH and incinerating the residue in a muffle furnace maintained at 550ºC for 4 hours. Crude protein (percentage total nitrogen x 6.25) was determined by the Kjeldahl method using 2.0 g of sample. Nitrogen free extract (NFE) was calculated by subtracting the total percentage of moisture, crude protein, crude fibre, crude lipid and ash.

D. Determination of anti-nutrients

Alkaloid determination: Begin by adding 5 g of the sample to a 500 ml beaker. Introduce 200 ml of 10% acetic acid in ethanol, cover the mixture, and let it stand for 2 hours. Afterward, filter the solution and concentrate the extract on a water bath until it reaches one-quarter of the original volume. Add 50 ml of concentrated ammonium hydroxide dropwise to the extract until a precipitate forms. Allow the solution to settle, collect the precipitate, wash it with ammonium hydroxide, and then filter. Finally, dry the residue and determine its weight.

Saponin determination: Initiate the process by defatting 10 g of the sample using acetone solvent through the soxhlet continuous extraction method. Extract the residue in the thimble with methanol solvent into a pre-weighed distillation flask using the soxhlet continuous extraction. Distill the extract to dryness and place it in an air oven to eliminate any remaining traces of methanol solvent. Re-weigh the flask to obtain the weight of the saponin in the sample.

Cyanide evaluation: Utilize the alkaline picrate method [12] to determine cyanide content. Measure the absorbance value at 490 nm using a spectrophotometer and determine the cyanide content by comparing it against a standard curve.

Tannin evaluation: Employ a spectrometric method[13] for tannin determination. Read the optical density at 700 nm using a spectrophotometer, and calculate tannin concentrations in the sample based on the tannic acid standard curve.

Phytate determination: Adapt the method reported by [14] for phytate quantification. Soak 4 g of powdered sample in 100 cm3 of 2% HCl (w/v) for over 3 hours before filtration. Take 25 cm3 from the filtrate and place it in a conical flask. Mix 5 cm3 of 0.3% NH_4SCN and 53.5 cm3 of distilled water, then titrate it against standard FeCl3 with 0.00195g Fe/cm3. Observe the formation of a brown-yellow color, which may persist for 5 minutes. Treat a blank in a similar manner.

E. Mineral evaluation

Two grams of each sample were subjected to ashing, and the resulting ashed samples were dissolved in HNO_3. The solution was then filtered through a number 42 Whatman filter paper into clean small plastic bottles. The filtrate was subsequently diluted to 100 ml with distilled water.

For the determination of magnesium (Mg), potassium (K), and sodium (Na), flame photometry was employed, utilizing specific metal bulbs. Phosphorus (P) was determined using the Vanado-molybdate method with a Corning Colorimeter 253 [11], while calcium was determined by titrating the filtrate with ethylene diamine tetra-acetic acid (EDTA) solution until the color transitioned from wine-red to a clear blue.

Quantitative analysis of chromium (Cr), copper (Cu), manganese (Mn), iron (Fe), and zinc (Zn) involved the preparation of standard metal solutions in 0.1M HNO_3. The glassware used in the analysis was pre-treated by leaching with 1:1 HNO_3 and rinsing with distilled water. The metal content in the freshly prepared samples was analyzed using a Jarrell Ash Model No. 82-270 Atomic Spectrophotometer, equipped with single-element hollow cathode lamps. An air/acetylene flame was utilized, and the metals were quantitated by comparing with standardized absorbance versus concentration curves.

F. Statistical analysis

The data obtained from the experiment was subjected to one-way analysis of Variance (ANOVA) and their significant differences were derived by using Duncan multiple Range Test, SAS package 2011 [15].

III. RESULTS AND DISCUSSION

A. Proximate analysis

The results of the proximate analysis presented in Table 1 revealed a significant difference ($P < 0.05$) in the proximate values among the three parts of *P. biglobosa*.

The seed exhibited the highest values for crude protein (CP) and ether extract (EE), recording 15.31±0.03% and 13.23±0.04%, respectively. In contrast, the pod displayed the lowest values for these parameters. Previous studies by [16] and [17] have noted that seeds, when used as alternative protein feed ingredients, are rich in crude protein, fat, and minerals, offering substantial health benefits. While the crude protein level in the pod may be insufficient for utilization in non-ruminant animals like poultry, it could potentially be combined with other ingredients such as leaf meals, akin to the practice with cassava tuber and peels that share similar crude protein levels. Furthermore, the leaf exhibited the highest ash value, while the seed had the least.

The findings also revealed that the pod exhibited the highest levels of crude fiber and nitrogen-free extract (NFE), while the seed had the lowest values for these parameters. Depending on the age and physiological condition of the animals, the elevated fiber content in the pod can be advantageous, as it has been suggested to aid in relieving constipation [18]. The substantial NFE content in the pod implies its potential as a valuable energy source when appropriately balanced with a high level of protein.

The leaf was identified as having the highest ash content among the various components. This suggests a higher mineral content compared to the seeds and pods of *P. biglobosa*. This observation aligns with earlier research on leaf meals conducted by [19] and [20]. The crude protein (CP) content of *P. biglobosa*, as determined in this study, surpasses documented reports for some seed meals used as alternative protein sources in broiler chicken production, such as velvet bean (1.61%), pigeon pea (2.33%), sword bean (2.94%), and *Canavalia plagiosperma* seed (5.94%) [21]. Additionally, the proximate components of the seed in this study are in line with values obtained by [22] for raw *P. biglobosa* seed.

B. Anti-nutrient composition

The results of the antinutritional factors analysis are presented in Table 2. Significant differences ($P < 0.05$) were observed in the values of alkaloid, saponin, tannin, and HCN across the three parts of P. biglobosa (pod, seed, and leaf), except for phytate. The pod exhibited the highest concentrations of alkaloid and tannin, with the least values for these antinutrients observed in the leaf and seed, respectively. Saponin and HCN were most concentrated in the leaf, while the seed displayed the lowest values. This outcome aligns with the findings of [23]. Saponin, although potentially detrimental to swine and poultry by causing irritation in the gastrointestinal tract and hindering protein digestion, also Now it is the time to articulate the research work with ideas gathered in above steps by adopting any of below suitable approaches:

IV. CONCLUSION

The findings of this study suggest that the P. biglobosa seed is more nutrient-rich and has lower levels of anti-nutritional components compared to the leaf and pod. However, its utilization in livestock feed may face significant limitations due to its concurrent use as a condiment in human food, thereby exacerbating the food-feed conflict. The nutrient content in the leaf and pod of P. biglobosa might be sufficiently adequate for livestock if appropriately balanced with other feed ingredients. The leaf can serve as a source of leaf protein, while the pod can contribute as an energy source. Alternatively, combining the leaf with the pod could enhance the protein level in the pod for livestock feed

possesses beneficial properties such as antibacterial, antiprotozoal, membrane-permeabilizing, immunostimulant, hypoglycemic, and hypocholesterolemic effects [24].

The levels of HCN in this study are consistent with the findings of [25], However, it is crucial to note that excessively high levels of HCN in feed materials can lead to a serious neurological disease known as Tropical Ataxic Neuropathy (TAN), as reported by [26]. The analysis of phytate revealed no significant difference across the three parts of P. biglobosa (pod, seed, and leaf) studied. The phytate levels obtained in this study (0.03±0.05 mg/g, 0.50±0.50 mg/g, and 0.04 mg/g) for the leaf, seed, and pod, respectively, may not pose a serious health challenge to livestock. This is because the reported level considered detrimental to animal health when consumed over an extended period is approximately 10-60 mg/g [27]. Phytates can impede the absorption of nutrients, particularly phosphorus, in the digestive tracts of animals [28].

C. Mineral composition

The mineral composition results of the P. biglobosa parts, as presented in Table 3, revealed significant differences ($P < 0.05$) among the studied components. However, similarities ($P > 0.05$) were observed in the values of sodium (Na) and manganese (Mn). The seed exhibited the highest calcium (Ca) levels, followed by the pod. The calcium level in the *P. biglobosa* seed in this study aligns with the findings of [29], who conducted research on *Canavalia plagiosperma* seeds. Furthermore, the pod had the highest values for phosphorus (P) and iron (Fe), while the seed and leaf recorded the lowest values for these parameters, respectively. The P. biglobosa leaf displayed the highest concentrations of potassium (K), magnesium (Mg), zinc (Zn), and copper (Cu).

Sodium (Na) plays a role in maintaining electric potential in body tissues, while magnesium (Mg), calcium (Ca), and phosphorus (P) are crucial for proper bone formation, especially in younger animals. Zinc (Zn) is a trace mineral essential for enzyme synthesis [30].

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Table 1
Proximate composition of the pod, seed, and leaf of *Parkia biglobosa* tree (on fry matter basis)

Proximate parameters (%)	Samples			
	Pod	Seed	Leaf	P-value
Crude protein	3.91±0.12^b	15.31±0.03^a	12.98±0.05^a	0.00
Ether extract	0.89±0.04^c	13.23±0.04^a	3.91±0.12^b	0.00
Crude fiber	8.85±0.1^a	1.77±0.02^c	6.54±0.01^b	0.00
Ash	2.36±0.09^b	1.99±0.04^c	3.16±0.01^a	0.02
Nitrogen free extract	75.14±0.11^a	56.86±0.03^c	64.52±0.09^b	0.00
Moisture	8.85±0.02^b	10.84±0.01^a	8.89±0.02^c	0.00

a, b = Means on the same row but with different superscripts are significantly different (P < 0.05)

Table 2
Anti-nutritional fraction compositions of pod, seed, and leaf of *Parkia biglobosa* tree

Anti-nutrient Quantitative anti-nutrient	Samples			
	Pod	Seed	Leaf	P-value
Alkaloid (mg/g)	19.06±0.09^a	2.09±0.54^b	1.19±0.02^c	0.00
Saponin (mg/g)	3.32±0.04^b	2.87±0.08^c	34.20±0.25^a	0.00
Tannin (%)	10.97±0.08^a	0.10±0.08^c	0.23±0.01^b	0.00
Phytate (mg/g)	0.04±0.01	0.50±0.50	0.03±0.05	0.47
HCN (mg/g)	0.10±0.01^b	0.07±0.00^c	2.22±0.30^a	0.00

a, b = Means on the same row, but with different superscripts are significantly different (P < 0.05)

Table 3
Mineral composition of the pod, seed and leaf of *Parkia biglobosa* tree

Mineral composition (mg/kg)	Sample			
	Pod	Seed	Leaf	p-value
Calcium	64.95±0.21^b	103.25±0.01^a	26.16±0.19^c	0.00
Phosphorus	127.83±0.20^a	97.58±0.02^c	115.95±0.00^b	0.00
Magnesium	125.29±0.14^b	96.34±0.06^c	137.22±0.03^a	0.00
Potassium	0.54±0.00^c	53.85±0.01^b	64.86±0.04^a	0.00
Sodium	0.01±0.00	0.02±0.00	0.01±0.00	0.06
Iron	15.02±0.24^a	10.31±0.23^b	1.59±0.04^c	0.00
Manganese	0.05±0.00	0.06±0.00	0.04±0.00	0.05
Cu	0.06±0.00^c	0.60±0.01^b	12.00±0.13^a	0.00
Zn	0.06±0.00^c	0.17±0.01^b	0.54±0.00^a	0.00

a, b, c = Means on the same row but with different superscripts are significantly different (P < 0.05)

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