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A comparative study of physicochemical, proximate and minerals analysis of some underutilized wild edible seeds used as condiments in Nigerian traditional soups

Salisu Abubakar [1, 2, *], Michael Afolayan [3], Charles Osuji [1], Alhassan Sallau [3] and Oluwadamilare Alabi [4]

[1] *Biotechnology Advanced Research Centre, Sheda Science and Technology Complex, P.M.B. 186, Garki, Abuja, Nigeria.*
[2] *Bayero University Kano, Faculty of Life Sciences, College of Natural and Pharmaceutical Sciences, P.M.B. 3011, Kano state, Nigeria.*
[3] *Chemistry Advanced Research Centre, Sheda Science and Technology Complex, P.M.B. 186, Garki, Abuja, Nigeria.*
[4] *Mathematics and Simulation Advanced Research Centre, Sheda Science and Technology Complex, P.M.B. 186, Garki, Abuja, Nigeria.*

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Abstract

The present study focused on Physicochemical, proximate and mineral analysis of some underutilized wild edible seeds (*Parkia biglobosa*, *Prosopis africanum* and *Acacia sieberiana*) used as condiments in Nigerian traditional soup and consumed by different tribal communities across the country. The seed samples were all pulverized and their properties determined appropriately. The physicochemical properties of the three seed samples were comparable with each other and the values obtained were similar and fell within the range observed for similar seeds and powdered samples used as condiments or for industrial purposes. Swelling and solubility profiles of the seed samples were quite high and reflected the high water absorption capacity of the pulverized seeds. Proximate analysis of the seed samples revealed a high protein content especially for *P. africanum* and *A. siberiana* while *P. biglobosa* had a high fat and carbohydrate content. Elemental analysis of the pulverized seeds was also carried out to determine the mineral contents and it was observed that the concentration of the essential elements were within safety limits while the heavy metals were very low with lead and chromium absent in two of the samples which was an indication of little or no toxicity of the seeds. The results of the various analysis carried out on the seed samples p\shows that all the three (3) study seeds are safe for consumption. These lend credence to their use as condiments and indicates that they can be further explored for other uses in the food industry

Keywords: *Acacia sieberiana*; Mineral analyses; *Parkia biglobosa*; physicochemical properties; *Prosopis africanum*; Proximate analysis

1. Introduction

Recently the urgency of the world food problem has thrown a challenge not only to the agriculturist and nutritionist but also to the foresters, to investigate the possibility of utilizing product from wild plants as additional source of protein, fat, vitamins, minerals and energy [1]. In order to guide the choice of the portion of wild fruits to be consumed and the provenance that will be very rich in term of their nutritional value, there is the need to chemically analyse the nutritional composition of these wild fruits.

The contribution of these wild edible fruits to the dietary need and nutritional requirement of people in the rural area cannot be overemphasized. Some wild fruits have higher nutritional values in terms of true protein compared with the

* Corresponding author: Salisu Abubakar
Biotechnology Advanced Research Centre, Sheda Science and Technology Complex, P.M.B. 186, Garki, Abuja, Nigeria.

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levels found in some cultivated fruits [2, 3]. Fruits of most tropical trees are good source of carbohydrates, minerals, fibre and vitamins and they also provide essential nutrient such as true protein and protein for human health [4].

In the search of rural dwellers to increase the protein level of their food, many wild edible fruits have been found to be good alternative. In many communities in Nigeria, edible fruits from wild plants are often taken as food or added to food as condiment to supplement important minerals and vitamins in human diets [1]. In most developing countries including Nigeria, the low income earners cannot afford protein rich foods from animal source to meet recommended dietary allowance hence, most of their diets consists predominantly of cereals and roots which do not provide good quality protein in diet [5,6].

1.1. Prosopis africana

Is one of the prominent tree in the study area, usually deciduous ranging from 8 to 20m in height? The tree has an open crown and drooping pale green foliage. Thorn less. The bark is grey, rough and very scaling, 4-8 mm thick and with orange-brown slash. The leaves are bipinnate, 7-15cm long with 2-4 pairs of opposite pinnae and 6-12 pairs of opposite leaflets per pinnae. Structurally, the fruits are dark brown in colour, shiny, indehiscent pods 5-20cm long, circular with 2-3cm in diameter, hard, thick and woody. The pods possess a thick pericarp consisting of three layers: a hard woody exocarp, a pulpy mesocarp and a thin septate endocarp between the seeds. Each pod contains 5-10 seeds in a septum. The seeds are embedded within a pulpy matrix (mesocarp) [7].

1.2. Acacia sieberiana

Is a perennial savannah tree 5-25m tall, with a rounded crown and trunk of 6m high? The bark is rough and yellowish with grey-brown scales. The branches bear short to massive 10cm long straight spines. The leaves are pinnate, usually sparsely hairy, bunched in to small clusters. The fruits are shiny brown in colour, straight or slightly curved with more or less parallel margins. Indehiscent, and release about 5-12 seeds. The seeds are about 1cm long, hard, flat and embedded in a yellowish-greenish pulp [7].

1.3. Parkia biglobosa

The most valuable tree in the study area, the tree is about 10-18m in height, sometimes reaching 20- 25m depending on the area. It has a rounded or umbrella shaped spreading crown, with drooping leaves and is without spines. The thick bark is grey with a scaly texture, with an orange coloured once slash. The leaves are dark green in coloured alternate, bi-pinnate and 20-40cm in length. Structurally, the fruits are slightly curved indehiscent pod of 15-cm long and 2-3cm wide. They are leathery, hang in clusters by the club-shaped fruit base, and are dry and brown in colour when ripe. Each pod contains 10-20seeds, which are embedded in a sweet, yellow, floury pulp. The seeds are hard, brown-blackish. 0.5-1cm long, it is globular-ovoid and slightly compressed laterally. Seed size varies within the pod, with those at the centre being largest [7].

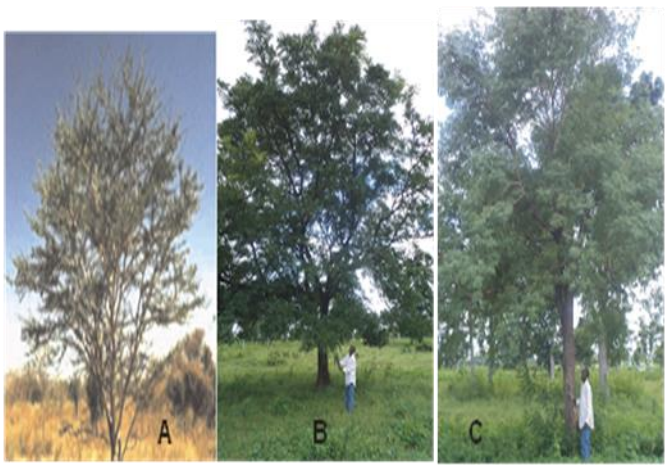

Plate 1 [A] *Acacia sieberiana*, [B] *Parkia biglobosa* [C] *Prosopis africana*

Despite the economic and nutritional values of these wild edible seeds in the collecting area there is scarce information on their nutritional values. Therefore, in this study, we have examined and compared the physicochemical and nutritional quality of pulverized seeds of these three wild edible seeds.

2. Material and methods

2.1. Sample Collection and Authentication

The samples were collected from a farmland in Kwali area council of Abuja, Federal Capital Territory of Nigeria which lies between the latitude of 8025` and longitude 6045` and 7045`E. The fruits containing the seeds were brought to the botanical garden of Biological Science Department, University of Abuja, which was identified by Mr. O. Segun a trained taxonomist and Verified by Professor O. Olorode (Botanist/Taxonomist) before taken to Chemistry Advanced Research Centre for proper processing and analysed.

2.2. Sample Processing

The samples were processed using earlier described procedure [7]. The pods of *P. biglobosa, P. Africana and Acacia sieberiana* containing the seeds were crushed using mortar and pestle and blown to separate them. Using laboratory hot plate (Hot Hc 1200, UK, Bibby) the seeds were boiled for 5 hours at 100 °C and dehulled after cooling. The dehulled seeds were oven dried at 60 °C for seventy two (72) hours using Memmert oven (Schutzari 40050-1p 20 Germany) to a constant weight. The dried dehulled seeds were pulverized using mortar and pestle, the pulverized powdered was then used for the physicochemical, proximate and minerals analysis.

2.3. Determination of physicochemical properties of pulverized seeds of *P. biglobosa, P. africanum and Acacia sieberiana*.

2.3.1. Swelling power

An earlier described method was used to determine the swelling power [8]. The powder sample (0.1 g) was weighed into a test tube and 10 ml of distilled water was added. The mixture was heated in a water bath at a temperature of 50 ℃ for 30 min with continuous shaking. In the end, the test tube was centrifuged at 1500 rpm for 20 min in order to facilitate the removal of the supernatant which was carefully decanted and weight of the powder paste taken. The swelling power was calculated as follows:

$$\text{Swelling power} = \frac{\text{Weight of powder paste}}{\text{Weight of dry powder sample}}$$

This was carried out over a temperature range of 50 °C – 95°C.

2.3.2. Solubility index

The method described earlier was also used to determine the solubility index [8]. Powdered sample (0.5 g) was added to 10 ml distilled water in a test tube. This was subjected to heating in a water bath with a starting temperature of 50 °C for 30 min. It was then centrifuged at 1500 rpm for 30 min. 5 ml of the supernatant was decanted and dried to constant weight. The solubility was expressed as the percentage (%) by weight of dissolved powder from heated solution. This was carried out over a temperature range of 50 ^{0}C – 95 ^{0}C.

2.3.3. Gelatinization temperature

This was evaluated using a method [9]. The powdered sample (1 g) was put in a 20 ml beaker and 10 ml of distilled water was added. The dispersion was heated on a hot plate. The gelatinization temperature was then read with a thermometer suspended in the powder slurry.

2.3.4. Foam Capacity

The method earlier described was used with slight modifications [10]. Powdered sample (1g) was homogenized in 50 ml distilled water using a vortex mixer (vortex 2 Genie set at shake 8) for 5 minutes. The homogenate was poured into a 100 ml measuring cylinder and the volume recorded after 30 s. The foam capacity was expressed as the percent increase in volume.

2.3.5. Emulsion capacity

Sample (1 g) was dispersed in 5 ml distilled water using a vortex mixer for 30 s. After complete dispersion, 5 ml vegetable oil (groundnut oil) was added gradually and the mixing continued for another 30 s. The suspension was

centrifuged at 1600 rpm for 5 min. The volume of oil separated from the sample was read directly from the tube. Emulsion capacity is the amount of oil emulsified and held per gram of sample [10].

2.3.6. Browning and charring temperature

The method described was used [11]. Some of the powdered sample was put into a capillary tube, the browning and charring temperatures were determined using a melting point apparatus with model Electro thermal 9100.

2.3.7. PH

A 20 % w/v dispersion of the sample was shaken in water for 5 minutes and the pH was determined using a pH meter.

2.3.8. Water holding capacity

The method described earlier was used to determine the water holding capacity [10]. The powder sample (5 % w/v) was dispersed in a pre-weighed centrifuge tube. The tube was agitated in a vortex mixer for 2 min. The supernatant was then discarded and the weight of the tube and hydrated sample taken. The weight was calculated and expressed as the weight of water bound by 100 g dry powder.

2.3.9. Bulk density

The bulk density of the powdered seed sample was determined using the method described with slight modification [12]. Powder sample (50 g) was poured into a 250 cm^3 calibrated measuring cylinder by means of a short – stemmed glass funnel. The volume occupied by the powder was noted to determine the bulk density.

$$\text{Bulk density (g/cm3)} = \frac{\text{Weight of sample}}{\text{Volume occupied}}$$

For the tapped density determination, the cylinder was tapped continuously using a ruler until a constant volume was obtained.

2.4. Proximate analysis

The proximate analyses were carried out in triplicate using a standard procedure [13].

2.4.1. Moisture content

The Moisture content was determined by heating 2 g of each fresh sample to a constant weight in a crucible and placed in an oven maintained at 105 ^{0}C till constant weigh observed.

2.4.2. Crude protein

The Crude protein was determined using micro Kjeldahl method. The Total protein was calculated by multiplying the evaluated nitrogen by 6.25.

2.4.3. Crude fat

Crude fat was determined by exhaustively extracting 5g of each sample in a Soxhlet apparatus using petroleum ether (boiling point range 40-60 ^{0}C) as the extractant.

2.4.4. Total ash

Total ash was determined by the incineration of 10 g samples placed in a muffle furnace maintained at 550 ^{0}C for 5 hours.

2.4.5. Crude fibre

Crude fibre was determined by digesting 2g of sample with H_2SO_4 and NaOH and incinerating the residue in a muffle furnace maintained at 550 ^{0}C for 5 hours.

2.4.6. Carbohydrate

The carbohydrate was given by subtraction i.e. (100 – [Percentage of Ash + Percentage of Fat + Percentage of Protein + Percentage of Crude fibre]). Each analysis was carried out in triplicate.

2.5. Elemental analysis

Two grams of each sample of seeds were dried and ashed at 550 ^{0}C for 5 hours. The ash was dissolved in 3 ml of HCL to 1 ml of HNO_3 until a clear solution was observed; the suspension was then filtered into a 100 ml volumetric flask and made it up to the mark (100 ml) using deionized water. Ca, Cu, Fe, Mg, Mn, Cr, Pb, Zn, Na and K contents were determined using Atomic Absorption Spectrophotometer (AAS Shimadzu AA 6800 model)

3. Results and discussion

The results of the physicochemical properties of all the pulverized seeds under consideration are shown in Table 1 below while the elemental analysis is shown in Table 2.

Table 1 Physicochemical properties of *P. biglobosa, P. africanum* and *A. sieberiana* pulverized seeds

Parameter	Value		
	P. biglobosa	***P. africanum***	***A. sieberiana***
Gelatinization temperature	70 ^{0}C	72 ^{0}C	72 ^{0}C
Foam capacity	12%	12%	8%
Browning temperature	232.9 – 235.6 ^{0}C	248.2 – 250.7 ^{0}C	250.6 – 251.8 ^{0}C
Charring temperature	273.7 – 280.7 ^{0}C	285.3 – 290.6 ^{0}C	280.4 - 293.1 ^{0}C
pH	4.8	4.6	5.22
Water holding capacity	75.16 ml	77.74 ml	64.96 ml
Bulk density	0.4950 g/cm^3	0.4831 g/cm^3	0.4785g/cm^3
Tapped density	0.5814 g/cm^3	0.5556 g/cm^3	0.5495g/cm^3
Emulsion capacity	70%	75%	68.5%

Table 2 Elemental analysis of *P. biglobosa, P. africanum* and *A. sieberiana* pulverized seeds

Test elements	Concentration in mg / g		
	P. biglobosa	***P. africanum***	***A. sieberiana***
Ca	6.0±2.0	13.04±0.00	2.02±0.5
Cu	0.05±0.01	0.641±0.05	0.19±0.1
Fe	0.624±0.3	0.442±0.01	0.11±0.01
Mg	1.97±0.3	0.964±0.01	3.93±0.03
Mn	0.072±0.01	1.071±0.05	0.02±0.0
Cr	Nil	Nil	0.02±0.1
Pb	Nil	Nil	0.001±0.00
Zn	0.096±0.01	0.041±0.01	0.15±0.1
Na	15.33±1.0	21.01±0.05	23.05±0.00
K	7.56±0.8	11.01±0.05	14.01±0.00

The swelling Power, Solubility index and proximate composition are shown in Figures 1, 2 and 3 respectively

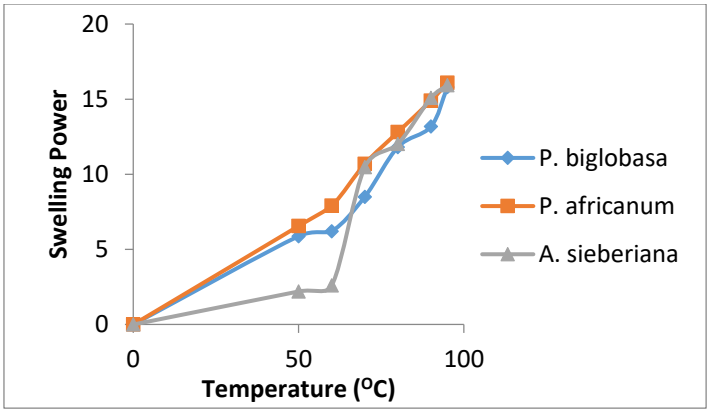

Figure 1 Swelling power of *P. biglobosa*, *P. africanum* and *A. sieberiana* pulverized seeds

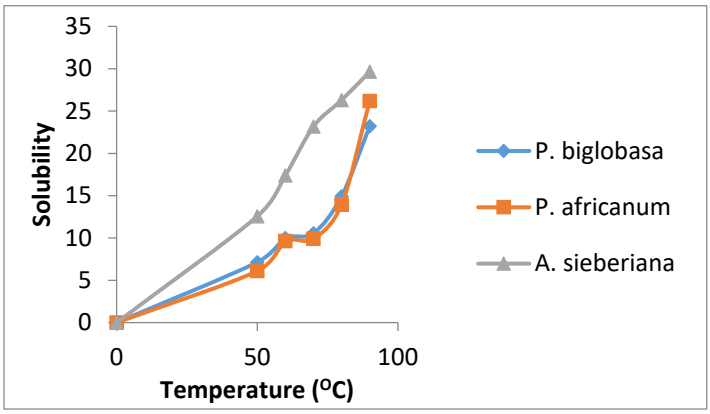

Figure 2 Solubility illndex of *P. biglobosa*, *P. africanum* and *A. sieberiana* pulverized seeds

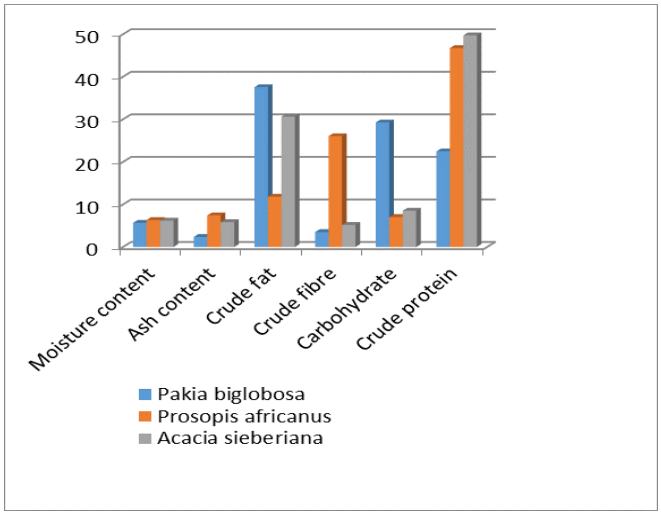

Figure 3 Proximate composition of *P. biglobosa, P. africanum and A. sieberiana* pulverized seeds.

The solubility and swelling profiles of the pulverized seed powders over a temperature range of 50 – 95^{0}C all show a temperature-dependent increase in both swelling and solubility as indicated in figures 1 & 2. They all show a high swelling power when compared to other powder samples like ginger and cola starch [8, 10] which is a reflection of the amorphous nature of the pulverized seeds. Swelling behaviour is usually an indication of the water absorption characteristics of a material during heating, hence a higher swelling power indicates a higher water absorption capacity. This is very much in line with the results obtained as the swelling power of *P. africanum* was the highest followed by *P. biglobosa* with *A. siberiana* having the least swelling power over the temperature range studied. This order is also observed for their water holding capacity. Generally, for all the seeds the swelling shows a steady increase between 50 ^{0}C – 95 ^{0}C however, *A. siberiana* has a very steep increase between 60 ^{0}C and 80 ^{0}C. This pattern may not exclusively rule out two sets of internal bonding forces that relax at different temperatures. A little crystalline region may also be present. Also high swelling power results into high digestibility and ability to use a sample in solution suggesting improved dietary properties and the use of the pulverized seed samples in a range of dietary applications [14, 15]. The solubility index for all the pulverized seeds increased steadily between 50 ^{0}C – 95 ^{0}C.

The gelatinization temperature of the pulverized seed samples were 70^{0}C for *P. biglobosa* and 72^{0}C for both *P. africanum* and *A. sieberiana.* This falls within the range of gelatinization temperatures commonly observed for starches and seed samples. The gelatinization temperature observed for all the samples is a reflection of the type of molecular association found in the pulverized seeds and is quite high. The pH values gotten falls within the pH range of 3 – 9 obtained for most starches used in the pharmaceutical, cosmetics and food industries [15]. The pH of *A. sieberiana* is however, considerably higher than that of the remaining two samples. The browning and charring temperatures indicates the temperature to which a material can be heated without changing colour or charring. This is observed to be quite high for all the pulverized seed samples and quite higher than the reported values for some starches-*Icacina and anchomanes* [10. 11, 16]. This shows that the seed samples can even be heated to a higher temperature without changing colour or charring. This quality will make them useful in industries that use flour at higher temperatures. The foam capacities of 12% and 8% is very high as against what is reported generally for starches [16] and the emulsion capacity is equally very high and an indication of the high fat content hence showing that all the pulverized seed samples may all be used as an emulsifier in food preparations. The water holding capacities of 75.16 ml, 77.74 ml and 64.96 ml in 100 g obtained for all the samples is comparable with earlier results reported for ginger, tigernut, *Icacina trichantha*, *Anchomanes difformis* and maize starch [9, 16]. This has a positive effect on the swelling capacity of the pulverized seed samples also and which is why the swelling powers were equally high. The bulk and tapped densities for all the samples are very low and quite lower than that reported for maize starch [17]. This shows that the samples can be compressed well. It will be observed that all the physicochemical properties of all the pulverized seed samples all fall within the same range and are comparable with each other. These show that the seed samples have similar properties and can be used interchangeably.

Proximate analysis of the pulverized seeds samples indicated a high protein content for all of them which is expected and shows a reason for their choice as food condiments. This also means that the seed samples can be used as source of infant food formula or introduced into the feeds of malnourished and underweight children to help them grow well and normal. In this case, *A. sieberiana* and *P. africanum* will be top choice since they have considerably higher protein content than *P. biglobosa*. *A. sieberiana* and *P. biglobosa* also have high fat content which reflects in their emulsion capacity. *P. africanum* has a rather high crude fibre content of about 25% among the rest. This can make it useful for animal feeds or to be used in foods for diabetics as high crude fibre content results in high digestibility. The high carbohydrate content of *P. biglobosa* pulverized seeds makes it energy giving among the rest [12]. All the pulverized seed samples have a very low moisture content and this gives it a high shelf value as it means that they can be stored for a long time without spoilage.

The elemental analysis result in table 2 for all the pulverized seeds shows that calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn), chromium (Cr), Lead (Pb), Zinc (Zn), Sodium (Na) and copper (Cu) were present in the pulverized seed sample of *A. sieberiana* at different concentrations while Chromium (Cr) and Lead (Pb) were absent in *P. biglobosa* and *P. africanum* with other metals present. The concentrations of the essential elements appear to be lower which is within safety limits according to W. H. O. [18]. The lower concentration of iron (Fe), zinc (Zn) and copper (Cu) is an indication of little or no toxicity of the seed samples as heavy metals are known to cause cancer, liver and kidney problems [19]. The elements magnesium (Mg), calcium (Ca), copper (Cu), and manganese (Mn) are used extensively in chemotherapy and are essential in human and animal health. Magnesium (Mg) and calcium (Ca) are known to help in bone and teeth development [20, 18]. The non – essential metals (lead and chromium) are entirely absent in *P. biglobosa* and *P. africanum* and very low in the *A. sieberiana* seed sample which is very good. The potassium content was 7.56±0.8 mg/g, 11.01±0.05 mg/g and 14.01±0.00 mg/g for *P. biglobosa*, *P. africanum* and *A. sieberiana* respectively while sodium content was 15.33±1.0 mg/g, 21.01±0.05 mg/g and 23.05±0.00 mg/g respectively. According to National Research Council [21], the Recommended Dietary Allowance of potassium is 1875-5625mg/kg for adults. Potassium is very vital

in regulation of water and electrolyte balance and acid-base balance in the body, as well as responsible for nerve action and functioning of the muscles. Deficiency of potassium leads to muscle paralysis [22]. Sodium is a very important mineral element that aids the transmission of nerve impulses as well as maintenance of osmotic balance of the cells. According to National Research Council [21], the Recommended Daily Allowance for sodium is 1100-3300mg/100g for adults. Deficiency of sodium may lead to dehydration or muscle cramp [22]. The high sodium and potassium content of the pulverized seeds sample makes it very good in human nutrition and lends credence to the reason why they are commonly used as condiments

4. Conclusion

Parkia biglobosa, *Prosopis africanum* and *Acacia sieberiana* are wild edible fruits bearing seeds, the seeds are commonly used among traditional people in Nigeria as food condiments. The pulverized seeds have been analysed in this study and shown to have very good proximate values for food and equally good essential elements contents with very little heavy metals which makes them safe for consumption. The physicochemical properties of the seed samples are comparable with each other and all within values gotten for other powdered samples being employed as industrial biomaterials. It is evident from our study that the seeds of these plants are good dietary supplements and can be further explored for other uses in the food and other industries.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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