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Potential Properties of Tiger Nuts (*Cyperus esculentus*) and African Elemi (*Canarium schweinfurthii*) as Food Substances in Plateau State, Nigeria

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Abstract
Food security poses a lot of threat worldwide, there is need to promote healthy nutrition among the large population using some underutilize food substances readily available in our communities. This research explored the potentials of these food crops available in Plateau State. Proximate composition, nutritional, antinutritional and trace metals in the oil extracted by cold extraction, were determined using the methods described by Association of Official Analytical Chemists (AOAC). Proximate composition revealed crude fat 37.26 ± 1.21mg/100g, ash 1.52 ± 0.02mg/100g in African Elemi, Tiger nuts, moisture was 48.50 ± 2.10 mg/100g, ash had 1.17 ± 0.07mg/100g. Mineral composition indicated, Ca in African Elemi (31.61± 1.63mg/100g), and Zn (2.40± 0.12mg/100g). Tiger nuts had Mg (102±0.00mg/100) and Mn (0.77±0.01mg/100g). Fe was (5.00±0.03mg/100g) in African Elemi and (1.91±0.01mg/100g) in Tiger nuts. Toxic metals (Cd, Cr and Pb) ranged BDL – 0.65± 0.01mg/100g in African Elemi and 0.06± 0.00 – 2.12± 0.04mg/100g in Tiger nuts. Toxicity in Tiger nuts was more pronounced than in African Elemi. Antinutritional analysis showed oxalate in African Elemi (4.67± 0.07mg/100g) and Tiger nuts (2.81± 0.14mg/100g) while phytate in African Elemi was 0.59 ± 0.01mg/100g and in Tiger nuts 0.10 ± 0.01mg/100g. Phytochemicals in Tiger nuts were carbohydrates, alkaloids, flavonoids, steroids, African Elemi, carbohydrates, steroids, terpenes, cardiac glycosides present. These food crops can be utilized in cosmetics, drug manufacture and food industries as a supplement.

Keywords: Food security, *Canarium schweinfurthii*, *Cyperus esculentus*, Proximate, nutritional, anti-nutritional, Plateau State.

1. Introduction

Vegetables and fruits are important sources of minerals, fibre and vitamins, which provide essential nutrients to the human body. It is also known that some fruits and vegetables have some anti-nutritional substance like tannins that diminish nutrient bioavailability, especially if they are present at high levels [1]. In most developing nations, numerous types of edible wild plants are exploited as sources of food to provide supplementary nutrition to the populace [2]. Several tropical fruits and vegetables are cultivated

in almost all parts of Northern Nigeria with a high nutritional value that plays important role in human nutrition. Also, researches conducted on the estimation of their nutritional value have shown that these vegetables and fruits are rich in minerals elements, vitamins, dietary fibres, anti-oxidants and diverse compositions of many nutritional and anti-nutritional substances [3]

Cyperus esculentus (Tiger nut) is a monocotyledonous plant which has its place in the family Cyperaceae, which is made up of over 4000 known species [4]. Its common names include; Tiger nut (English), 'Aya' (Hausa), Chufa sedge (English), Yellow nut sedge (English) and Earth almond (English). It grows mainly in the tropical and warm temperate regions of the world. Major areas found includes, Spain, Nigeria, Senegal, Guinea, and Cameroun [5]. The tubers are edible and are consumed fresh, dried or in roasted form in some countries like Burkina Faso and Nigeria. Tiger nut tubers are also processed into milk called tiger nut juice (Kunu Aya) in Nigeria [6].

Nowadays, Tiger nuts are also cultivated in Northern Nigeria, Niger, Mali, Senegal, Ghana, and Togo where they are used primarily eaten uncooked as a side dish [7]. However, in many countries, *Cyperus esculentus* is considered a weed and it is underutilized [8].

It has a good flour and can be an additive for the baking industry, as its natural sugar and high fiber content makes the product very healthy. Tiger nut flour does not lose any of its nutritional properties in the milling process [9]. 'Dakuwa' is a snack produced majorly in northern Nigeria though consumed in other parts of the country. It is made of maize, groundnut, sugar, spices and tiger nuts can be incorporated [10]. Tiger nut milk is a very nutritive and energetic drink, both for young and old. It is a tremendously high in starch, glucose and proteins. Also rich in minerals like Potassium, Phosphorous, Vitamins E and C. It contains a large amount of Oleic acid and is cardiac preventive. It defends the internal mechanisms and prevents both constipation and diarrhoea. Tiger nut milk has never been found to produce allergy [11]. It has also been reported that, tiger nut, with its inherent nutritional and therapeutic advantage, could serve as good alternative to cassava in baking industry [12]

Another highly under utilized price plant is the Africsn Elemi, perennial plant found in Africa referred to as black olive, African olive, black elemi [13]. In English, it is commonly known as purple canary tree, bush candle among others. The fruit is a small drupe, bluish-purple, glabrous, 3–4cm long, and 1–2cm thick. The calyx is persistent and remains attached to the fruit. The tree has geographical distribution throughout Africa, native species are found mostly in the Western and Central African Countries like Angola, Cameroun, Ethiopia, Ghana, Guinea-Bissau, Liberia, Mali, Senegal, Sierra-Leone, Sudan, Tanzania, Togo, Uganda, Zambia and Nigeria. The pulp contains 71% palmatic acid and 18 % oleic acid which is edible [14]. In Nigeria, the tree is found in parts of Bauchi, Plateau, Niger, Southern Kaduna and Oyo States [13]. In Plateau State, it is found in Pankshin, Bokkos, Jos North, Jos South and Jos East. It also has a hard stone seed that is edible and oily [15]. The residue from the combustion of the resins is gathered as carbon black that can be used for producing ink. The seeds can be used for ornamental purposes such as making necklaces, bangles and costumes [16]. The wood is used for constructing boats, mortars, flooring and furniture [17]. Tiger nut and African Elemi has been for many years one of the underutilized food crops in Nigeria. They are very important food crops that have great potential in managing, preventing and eliminating malnutrition (macronutrient and micronutrient deficiencies) to address food insecurity.

The aim of this research was therefore to determine the proximate composition, nutritional and anti-nutritional contents of oil extracted from *Cyperus esculentus L.*and *Canarium schweinfurthi.* The oil from African Elemi and Tiger nut were subjected to proximate analysis,mineral content to create awareness on the need to increase production and utilization of locally available food resources. Tiger nut and African Elemi could demonstrate to aid in solving major nutritional problems through exploitation of its nutritional and economic potentials.

2. Materials and Methods

Sample Collection and Preparation

Canarium schweinfurthii (African elemi) was purchased from a local farm in Dilla village, Pankshin local government area of Plateau State and was brought to the Chemistry laboratory at the University of Jos, Nigeria. It was then washed with distilled water and placed in a bowl of warm water for 15 minutes for easy removal of the

pulp after which the water was drained from the fruit. The pulp was then separated from the seeds and dried in an oven at 105℃ for 5 hours after which it was removed and cooled in a dessicator. After cooling it for 1 hour it was divided into two parts, one part was ground into fine powder and the other part kept in an airtight container at room temperature for further use.

Cyperus esculentus (Tiger nut) was purchased from Terminus market in Jos, Plateau State. It was sorted out to remove stones, spoilt nuts and then rinsed with distilled water after which it was air dried for three weeks on a cardboard paper on the laboratory bench at room temperature. The dried nuts were then divided into two parts one was grounded with a mortar and pestle into powdered form and the other part was kept at room temperature for further use.

Proximate Analysis

The proximate content including moisture, crude protein, ash, crude fibre, lipid and carbohydrate of C*yperus esculentus* and C*anarium schweinfurthii* were determined using the standard methods as described by Association of Official Analytical Chemists [18]. Oil was extracted from the samples after oven drying at 70^{o}C using a cold Press Machine. The oil was stored in an airtight container and kept at room temperature for further analysis. The yield of oil extracted was calculated as follow

Weight of initial sample=X

Weight of bottle =Y

Weight of bottle + extract = Z

Weight of extract (W) = (Z-Y)

Percentage oil yield = Weight of oil extracted/Weight of sample X 100%

= W/X * 100%.

Determination of Mineral Content

One gram (1g) each of grinded powdered *Cyperus esculentus* and *Canarium schweinfurthii* were weighed seperately and placed in kjedahl flasks, 20 cm^3 of HNO_3, 2 cm^3 of H_2SO_4 and 1 cm^3 of $HClO_4$ were added into the kjedahl flasks inside a fume cupboard and heated on a heating mantle until a clear solution was obtained. The samples were allowed to cool and filtered in a 100 cm^3 flask; a blank was also prepared and kept for AAS analysis.

Determination of Antinutritional Content

Preparation of Alkaline Picrate Solution

One (1) g of picrate and 5 g of sodium carbonate (Na_2CO_3) was dissolved in warm water in 200 cm^3 flasks and the whole volume was made up to 200 cm^3 with distilled water.

Determination of Cyanogenic Glycoside

The alkaline picrate method by Masimal et al. (2018) was adopted. 5 g of *Cyperus esculentus* and *Canarium schweinfurthii* samples was weighed each and dissolved in 50 cm^3 distilled water in corked conical flasks. The mixtures was allowed to stay overnight and then filtered. The extracts (filtrates) were then collected and labeled A and B respectively. Different concentrations of hydrogen cyanic acid (HCN) were prepared containing 0.02 to 0.10 mg/cm^3 cyanide. The absorbance of each was taken in a spectrophotometer at 490 nm and the cyanide standard curve was plotted. 1 cm^3 of each sample filtrate and standard cyanide solution was measured into three (3) test tubes respectively and 4 cm^3 of alkaline picrate solution was also added to each and incubated in a water bath for 15 minutes. A reddish brown colour was developed; the absorbance of each content in the test tubes was then taken in a spectrophotometer at 490 nm against a blank containing only 1 cm^3 distilled water and 4 cm^3 alkaline picrate solution. The cyanide content for each sample was extrapolated from the cyanide curve.

Preparation of casein Solution

A solution of 7.0 cm^3 glacial acetic acid in 50 cm^3 of water was prepared. 600 g of skimmed milk was placed in a 1000 cm^3 beaker and heated to 110^{o}C. Afterwards acetic acid was added dropwise with continuous stirring using a glass rod. The casein was transferred into a blender with 500 cm^3 of water and was blended and filtered; the casein was washed with ethanol. The casein solution was used for the determination of trypsin inhibitor.

Determination of Phytate

The phytic acid and tanins were determined using the procedure described by Markkar et al. [19].

Preparation of Folinciocalteu Reagents

One hundred (100) g of Sodium tungstate ($Na_2WO_4.2H_2O$) and 25 g of Sodium molybdate ($NaMbO_4.2H_2O$) was added in 700 cm^3 of H_2O placed in a 1L beaker containing 25% Orthophosphoric acid H_3PO_4, 100 cm^3 of concentrated HCl was added into the 1L beaker under reflux for 10 hours. It was cooled and 150 g of Lithium Sulphate (Li_2SO_4) dissolved in 50 cm^3 H_2O afterwards 4 drops of liquid bromine was also added and heated for 15 minutes to remove bromine. The mixture was then cooled and diluted with H_2O and filtered, a golden yellow color reagents was obtained it was stored in a brown bottle which was then diluted 1 volume in 200 cm^3 distilled H_2O before it was used for tannin determination. Oxalate was determined by using the method of Kasimala et al. (2018).

Phytochemical Screening

The extract of C*yperus esculentus* and C*anarium schweinfurthii* was subjected to phytochemical test for the presence of alkaloids, saponins, tannins, flavonoids, carbohydrate, steroids, terpenes, anthraquinones, free anthraquinones and cardiac glycosides using the procedures by Trease and Evans, [20]. Saponins and cardiac steroidal glycosides by [21], steroids and terpenes by [22], [23].

3. Results

The result of the proximate analysis is summarized in Table 1. The percentage moisture content of *Canarium schweinfurthi* and *Cyperus esculentus* were found to be (32.50±0.98 and 48.50±2.10) %. The protein content was 11.78±0.72% for *Canarium schweinfurthii* and 7.42±0.21% for *Cyperus esculentus*. The crude fibre content obtained from the *Canarium schweinfurthi* was 2.79±0.28% and 14.21±0.32% for *Cyperus esculentus.* The carbohydrate content was found to be 14.15±0.32% for *Canarium schweinfurthi* and 11.20±0.57% for *Cyperus esculentus.*Like most oilseeds, *Canarium schweinfurthi* is relatively higher in Carbohydrates compared to *Cyperus esculentus.* This can make it a good blend with starchy foods. The proximate composition revealed a low ash content of 1.52±0.02% for *Canarium schweinfurthi* and 1.17±0.04% for *Cyperus esculentus.*

Table 2 presents theelemental composition. Calcium which forms component of bones and teeth, is necessary for blood clotting and muscle contraction was found to be 31.67±1.63 mg/100g in *Canarium schweinfurthi* and 1.14±0.05 mg/100g in *Cyperus esculentus.* Manganese which functions in bone formation, as well as regulates enzymes in amino acid, cholesterol and carbohydrate metabolism was found in trace quantity (0.77±0.07 mg/100g) in *Cyperus esculentus* and higher (3.33±0.21mg/100g) in *Canarium schweinfurthi.* However, the concentration of zinc was 2.40±0.12mg/100g in *Canarium schweinfurthi* and 1.39±0.01 mg/100gin *Cyperus esculentus* while lead was below detectable limit in *Canarium schweinfurthi* and 2.12±0.04 mg/100g in *Cyperus esculentus.* Cadmium was found in trace amount in both *Canarium schweinfurthi* (0.07±0.00 mg/100g) and *Cyperus esculentus* (0.08±0.00 mg/100g) respectively.

Table 3 summarizes the anti-nutritive factors of *Canarium schweinfurthi* and *Cyperus esculentus*. The phytate level is 0.59±0.01 % in *Canarium schweinfurthi* and 0.10±0.01% in *Cyperus esculentus*. The anti-nutritional factors shown indicate that the level of oxalate is 4.67±0.07mg/g in *Canarium schweinfurthi* and 2.81±0.14mg/g in *Cyperus esculentus.* The study reveals the tannin level of *Canarium schweinfurthi* as 0.72±0.02% while for *Cyperus esculentus was* 0.32±0.02 %. Saponin content of the *Canarium schweinfurthi was* 0.61±0.04% and *Cyperus esculentus was* 0.80±0.32 %. The alkaloid content was 0.69±0.00 % and 0.40±0.46 % for *Canarium schweinfurthi* and *Cyperus esculentus* respectively.

The oil yield is presented in Table 4, from the results *Cyperus esculentus* produces high quantity of oil (47.00±0.02) %. It revealed that *Canarium schweinfurthi* is very rich in oil (58.00±0.21%) which is higher than (47.00±0.02%) that of *Cyperus esculentus*. The high oil content suggests that the fruit can be exploited as raw material for the manufacture of edible oil, margarine and some pharmaceutical products.

4. Discussion

Ayoade et al. [24] noted that *Canarium schweinfurthi* oil compared well with other existing oils as edible vegetable oil. According to the report, the oil contains several fatty acids like oleic, linoleic, palmitic and stearic acids. It has a relatively high fat content which makes it an important source of cheap energy to those who consumes it. The moisture content was slightly different from the reports of Ehirim et al [25]. High moisture content of oil could lead to microbial spoilage if not properly stored since the moisture content of any food could be an index of its activity. This implies that organisms that caused spoilage are likely to survive leading to short shelf life of the oils.The oils could also be re-distilled to reduce the water content to extent the shelf life.

Ayoade et al. [24] had reported a higher protein content of 12.67±0.01% for *Canarium schweinfurthii*. This could be due to varietal and environmental differences or analytical procedure.The higher protein level of the *Canarium schweinfurthi* shows that the pulp can be a useful protein supplement in baked products and other several foods.This will help to meet the protein needs of a good proportion of people especially children who consume this fruit readily, thereby reducing the problem of protein mal-nutrition.

The fibre content is lower than the value of 2.81 - 2.94% recorded for African pear at different locations of Southeastern Nigeria [26]. Adequate consumption of fibre diets is reported to have beneficial effect on the muscles of the large and small intestine. Other advantages of adequate fibre diets include reducing obesity, prevention of diverticulitis diseases, reducing constipation, lowering cholesterol concentrations and reducing blood sugar for diabetics [25]. Consumption of this fruits especially *cyperus esculentus* therefore will greatly enhance the health status of the people especially the rural dwellers who are great consumers.

High ash value is a reflection of the rich mineral content of the fruits. Minerals are needed for proper body development and functioning [25].

Mineral elements are present in *Canarium schweinfurthi* and *Cyperus esculentus* which make them good sources of these nutrients. Calcium is essential for building the living cells that make the human body balance. It promotes a healthier cardiovascular system and helps in maintaining the volume of water necessary for life processes. Both are lower than 160 mg/100g for *D. microcarpum* pulp [27] and *Canarium schweinfurthi* is higher than 30.0 mg/100g reported by Eromosele et al., [28] for *Canarium schweinfurthi*. The availability of calcium in the body depends on calcium to phosphorus ratio and presence of anti-nutritional factors. For good calcium intestinal absorption, Ca:P ratio of 1:1 is required [27]. Calcium is required in the body for proper bone formation, maintenance and growth, tooth formation and contraction of muscles. This result points out that they both have the potentials of meeting the calcium needs of individuals when consume alongside other calcium-rich foodstuffs.

The *Canarium schweinfurthi* and *Cyperus esculentus* had appreciable amount of iron values, its consumption could be encouraged for menstruating and lactating women. Sodium content values in combination with potassium is involved in proper acid-base balance maintenance and nerve transmission in the body system. With the high iron content of *Canarium schweinfurthi* and *Cyperus esculentus*, and its relative cheapness, rural pregnant women and children should be encouraged to consume much of it. They can also be incorporated into manufactured products like baked foods as a means of iron supplementation. Iron is an essential component of haemoglobin and myoglobin [25], and aids in transporting oxygen in and carbon (IV) oxide out of the body.

*Cyperus esculentus*is also said to be recommended for those who have heavy digestion, flatulence, dysentery and diarrhea because it provides a lot of digestive enzymes diuretic, stimulant and tonic in addition to being thirst quencher [10]. *Cyperus esculentus* milk is said to be rich in minerals, like phosphorus, calcium and magnesium, iron and in vitamin C and E which are essential for body growth and development. The energetic value (100 cal/100g) of *Cyperus esculentus* milk makes it a very good energy drink. It is very important because it does not contain lactose or gluten [11].

The phytate level is lower than 1 - 6% found in rapeseeds (Bhukya et al., 2019). Phytic acid forms insoluble salt with essential minerals like calcium, magnesium and iron in food, rendering them unavailable for absorption into the bloodstream, Phytates are destroyed by proper heat treatment [25] and hydrolysis.

Oxalate is found in fruits, vegetables and cereals. It is of concern because high oxalate in diet can increase the risk of renal calcium absorption. Ehirim et al. [25] reported that on a dry weight basis, Nigerian vegetables might be

superior to milk as gross sources of calcium except that the calcium is not available due to the presence of oxalic acid which is bound as insoluble calcium oxalate. According to Ehirim et al [25], oxalic acid in food can be completely eliminated by cooking sufficiently. Inuwa et al. [29] reported tannin value of 0.37% for Ground nut oil and 0.13% for Palm oil which are consumed as a human food. Tannin may decrease protein quality by decreasing digestibility and palatability. Other nutritional effects of tannin include damage to the intestinal tract, toxicity of tannins absorbed from the gut and interference with the absorption of iron and a possible carcinogenic effect. Ehirim et al [25] stated that tannins are responsible for the astringency of many foods such as apples, pears, tea and cocoa.

Saponins are characterized by their bitter or atrigent taste, foaming properties and their hemolytic effect on blood cells. Although saponins are highly toxic to fish and other aquatic cold blooded animals, acute saponin poisoning in humans is rare. According to Ehirim et al [25], while there are suggestions that the consumption of saponin should be encouraged because of their hypocholesterolemic activity (cholesterol lowering), forage saponins have been reported to cause toxic and aneroxic effects in rats and swine. Saponins are not destroyed by cooking; however alkaline washing or dry scouring and abrasive dehulling have been suggested as techniques for saponins reduction in legumes [25].

This low level of alkaloid cannot cause any nutritional problems to consumers of both fruits, since they are mostly processed and boiled before eating. Ehirim et al *[25*] reported that simple boiling removes alkaloids present in most cultivated species of plant foods. Alkaloids are basic natural products occurring in plants, generally found in the form of salts with organic acids. Ehirim et al, [25] stated that about 10-20% of all higher plants probably contains alkaloids.

The edible and stable oil obtained from the tuber is said to be superior oil that compares favourably with olive oil [30]. *Cyperus esculentus* oil has golden colour and a nutty taste which makes it ideal for different users. The use of cold pressed machine gave a reasonable percentage of oil extracted from *Canarium schweinfurthii (*58.00±0.21) % by weight in grams. This implies that *Canarium schweinfurthii* is richer in oil than *Cyperus esculentus*. The colour of *Canarium schweinfurthii* oil is greenish yellow.

The result of phytochemical screening is presented in Table 5. The result shows the presence of Alkaloid, Carbohydrate and steroids in *Cyperus esculentus*. Alkaloids are known to have antimicrobial activity, as well as other physiological activities [31]. Alkaloids are known for their toxicity, but not all alkaloids are toxic. They inhibit certain mammalian enzymic activities such as those of phophodiesterase, prolonging the action of Cyclic adenosine monophosphate (CAMP). They also affect glucagons and thyroid stimulating hormones, while some forms have been reported to be carcinogenic [32]. Some have been used either as an analgesic, antispasmodic, bactericidal agents [32]. The result of the determination of phytochemical test indicated that the *Cyperus esculentus* tuber possess some biologically active compounds which could serve as potential source of vegetable drugs in herbal medicine. These phytochemicals exhibit diverse pharmacological and biochemical actions when ingested by animals [4]. They are usually present at low concentration in edible fruits, nuts, tubers and vegetables. From the phytochemical screening results, there is the presence of steroids, terpenes and cardiac glycosides in *Canarium schweinfurthii*. It should be noted that steroidal compounds are of importance and interest in pharmacy due to their relationship with compounds as sex hormones. This may be the reason why the leaves of the plant are used as vegetable for pregnant women or breast feeding mothers to ensure their hormonal balance.

5. Conclusion

The findings indicate that the *Cyperus esculentus* (Tiger nut) and *Canarium schweinfurthii* (African elemi) which are popularly eaten raw or cooked respectively are rich in important food nutrients like calcium, zinc, iron and magnesium. Their cultivation and consumption should be encouraged in commercial quantity. *Canarium schweinfurthii* (African elemi) and *Cyperus esculentus* (tiger nut) contains phenolic compounds, terpenes, steroids, cardiac glycosides, flavonoids, alkaloids account for its multiple properties and uses in traditional medicine. Low level of antinutitional content indicate it is nontoxic to human body.

The percentage oil yield shows that the two food crops are good sources of cooking oil. The fatty acids profile of the *Cyperus esculentus* and *Canarium schweinfurthii* oil shows that the oil is mostly unsaturated and can be useful industrially

Authors Contributions

DJD and HAP had the original idea. AGE, OE, MSM and SSJ participated in the design, sampling analysis and drafting of the manuscript. All the authors participated in writing the manuscript and the eventual approval of the final version of the manuscript

Competing Interests

The authors declare that they do not have any competing interest

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