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Characterization of Some Edible Medicinal Plant Parts for Metal Contents and Nutritious Chemical Constituents

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Abstract: The fruits, seeds, pulps and leaves of *Eucalyptus camaldulensis, Eucalyptus citriodora, Gmelina arborea, Parkia biglobosa and Jatropha gossypifolia* were differently investigated and characterized for proximate constituents, metals and fatty acids with a view to evaluating their dietary potentials. Results obtained show that all the plant parts contained nutritious chemical compounds. The ranges of the proximate constituents on dry weight basis (g/100g) are: moisture (5.99-10.90), ash (1.92-8.79), crude fibre (9.49-25.16), crude protein (3.07-11.38), crude fat (4.01-7.48) and carbohydrate (40.69-66.08). The mineral contents of the various plant parts in mg/100g are: Fe (1.03-912.90), Cu (1.50-58.50), Mn (10.20-451.50), Mg (156.60-166.20), K (31.20-374.70) and Zn (1.80-396.00). The fatty acids profile of the various plant parts showed different percentages of saturated (12.38-19.11), monounsaturated (17.46-42.07) and polyunsaturated (18.66-45.14) fatty acids. It is observed that the chemical compounds in the medicinal plants could be of complementary dietary advantages.

Keywords: *Eucalyptus camaldulensis, Eucalyptus citriodora, Gmelina arborea, Parkia biglobosa, Jatropha gossypifolia*, dietary values, medicinal plants.

Introduction

Medicinal plants are worldwide considered as key sources of drugs for the treatment of various ailments[1-3]. The medicinal values of these plants lie in some of the chemical substances they possess which produce a definite physiological action on the human body[4]. They play a major remedy in the traditional system of medicine and have been, since antiquity, widely used in medical practices. Many of the indigenous medicinal plants have also been used as spices and food plants[5,6].

One of these many medicinal plants is *Eucalyptus*, a plant which belongs to *Myrtaceae* family and comprises about 900 species[7]. This genus has a long history of application in pharmaceutical and cosmetic industries[8]. Two of the Eucalyptus species are *Eucalyptus camaldulensis* and *Eucalyptus citriodora. E. camaldulensis,* also known as river red gum, which is a perennial, single-stemmed, large-boled, medium-sized 45m-tall tree[9]. The fruit is heavily grazed on by rabbits and kangaroos during prolonged dry season when feed is scarce[10]. *E. citriodora*, also known as lemon-scented gum, is an evergreen tree growing to 45 m at a fast rate. The flower, which is a hermaphrodite, is pollinated by bees. The fruit is slender and with stem and unusual sword-shaped silvery-green-foliage, which becomes tinged with red as fall approaches.

Parkia biglobosa, is another edible and valuable plant of the family *Mimosaceae*, popularly known in Nigeria as African locust

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bean tree. The Yoruba speaking populace refer to it as "Igba" or "Irugba", the Hausa speaking group refer to it as "dorowa" and the Igbo speaking as "Origili". The leaves of *P. biglobosa* are used in preparing lotion for sore eyes and also used for cardiac conditions as they contain an appreciable amount of cardiac glycosides[11]. The high nutritional potential of locust bean pulp, such as its proteins, carbohydrates, carotenoids (pro-vitamin A) and the mineral contents, justifies its use as supplement in infant feeding in northern Benin[12].

Also, *Gmelina arborea* is a large rapidly growing and deciduous tree which was introduced into West Africa from Asia and is common in Ghana, Myanmar, Thailand, Laos, Cambodia, Malaysia and Nigeria[13]. The fruit is about 2.5 cm long, smooth, dark green, turning yellow when ripe and has a fruity smell. The leaves are simple, opposite, more or less heart-shape, 10-25 cm long and 5-18 cm wide. Leaf decoction is used as wash for fevers and internally for dysentery, fever or convulsion and the seeds are also used medicinally in some parts of West Africa[14].

Another medicinal plant of interest in this study is *Jatropha gossypifolia.* It is a tropical plant belonging to the family *Euphorbiaceae*, which is similar to *J. curcas,* but the leaf stalks are covered with coarse dark brown hairs with the young leaves being sticky and the flowers purple. It is an ornamental plant naturally used in many tropical areas. The root, stems, leaves, seeds and fruit of the plant are widely used in traditional folk medicine in many parts of Africa. The seed oil of the plant has its use as an ingredient in the treatment of rheumatic conditions, itch, skin diseases and in the treatment of fever, jaundices and gonorrhoea and also as a mouth wash[15].

Most of the research on medicinal plants have been in the area of phytochemistry, pharma-cognosy and horticulture. However, various medicinal plant species are also consumed as food along with their medicinal benefits. Therefore, evaluating the chemical compounds for dietary significance can help understand the worth of these plant species[16]. However, little or no information is available on the nutritional qualities and dietary values of the leaves, fruits and seeds of these plants, used as garden, ornamental, house plants and sometimes for medicinal purposes. This study, therefore, sought to characterize eight different parts of these medicinal plants in an effort to evaluate their nutritive chemical compounds and dietary potentials.

Materials and Methods

Sample Collection and Preparation

E. camaldulensis fruit was collected from Eucalyptus plantation at Orisunbare junction, Maryland Ogbomoso and *E. citriodora* was collected in front of Ogbomoso North Local Government Secretariat along Ilorin road Ogbomoso, Oyo state, Nigeria. *J. Gossypifolia* was detached from its tree at California Area, Idi Oro Ajegunle in Ogbomoso Oyo- State. Ripe samples of *P. biglobosa* leaf and seed pulp were collected from YOACO area, in the vicinity of the campus of Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Nigeria.

Fresh leaves and seeds of *G. arborea* were collected in the vicinity of Department of Pure and Applied Chemistry, LAUTECH, Ogbomoso, Oyo state, Nigeria. The samples were dried under laboratory shade for 3 weeks. They were ground to powder using a KW 10 food blender and stored in an air tight container prior to analyses.

Proximate Composition

Procedures of Association of Official Analytical Chemists, AOAC (1990)[17] were adopted for the determination of proximate composition. Moisture content was determined by heating 2.0 g of each sample to a constant weight in a crucible placed in a thermostatically controlled oven maintained at 105 ^{o}C. Ash was determined by the incineration of 1.0 g of each sample in a muffle furnace maintained at 550 ^{o}C until grey ash results. Crude fat was obtained by exhaustively extracting 5.0 g of the dried sample in a Soxhlet apparatus using petroleum ether (40-60 ^{o}C) for 6 hours. Crude protein (%total nitrogen × 6.25) was determined by the Kjeldahl method, using 2.0 g of dried, defatted samples. Crude fibre content was estimated by consecutive acid and alkali digestion of sample followed by washing, drying and ashing at 600 ^{o}C. Carbohydrate content was calculated by difference.

Determination of Nutritive Value of Samples

Nutritive value of the dry powder of the samples was calculated based on the energy value available per kg of the macronutrient. Protein, carbohydrates and fats yield 4.0, 4.0 and 9.0 kcal of energy per g, respectively. The nutritive value (NV) was calculated as [(4 × %protein) + (4 × %carbohydrate) + (9 ×%fat)][18].

Determination of Mineral Elements

Each of the ground samples was weighed (1.0 g), nitric:perchloric acid (20 mL) in a ratio of 2:1 (v/v) was added. The mixture was heated and digested. The resultant digestate was washed into a 50 mL standard flask with deionized water and made up to the mark. This solution was analyzed in triplicate for its elemental composition using atomic absorption spectrophotometer (Buck Scientific 200 A model, Buck Scientific Inc., East Norwalk).

Extraction of Oil for Fatty Acids Composition and Analysis

The dried and ground samples (5 g each) were placed in a cellulose paper cone and extracted with n-hexane using Soxhlet extraction apparatus for 6 hours accordingly. The solvent was removed *via* a rotary vacuum distillation at 40-50 ^{o}C. 0.1g oil sample was esterified for 5 min at 95°C with 3.4 mL of 0.5 M KOH in dry methanol and neutralized using 0.7 M HCl and 3 mL of 14% boron trifluoride in methanol; then heated for 5 min at the temperature of 90 °C to achieve complete methylation process. The fatty acid methyl ester was thrice extracted from the mixture with redistilled n-hexane. The content was concentrated to 1 mL for gas chromatography analysis and 1 µL was injected into the injection port of the gas chromatography (HP6890 Powered with HP Chem Station Rev. A 09.01 (1206) Software) equipped with a flame-ionization detector and a 30m×0.25mm column coated with a 0.25 µm film of HP INNOWAX. Split injection (split ratio 20:1) was performed, with nitrogen as carrier gas at a flow rate of 22 psi. The column temperature was maintained at 60°C for 1 min after injection, then programmed at 12°C/min up to 250°C, held there for 2 min and then heated at 15°C/min for 3 min and then held constant for 8 min. The injection port temperature was 250 °C and the detector temperature was 320 °C. The fatty acids were identified by comparing their retention times with those of standards and the content of fatty acids was expressed as percentage of total fatty acids [19].

Statistical Analysis

Means and standard deviations were calculated for replicate determinations Significant difference between parts of the medicinal plant (fruit, seed, leaf and pulp) was established using Analysis of Variance (ANOVA) at 95% confidence.

Results and Discussion

The proximate composition (%) of the nutrients in various parts of *E. camaldulensis, E. citriodora, G. arborea, J. gossypifolia and P. biglobosa* show varied levels (Table 1). Highest content of moisture (10.90%) was recorded in the leaf of *J. gossypifolia*, followed by pulp of *P.biglobosa* (9.63%) while the least moisture content was recorded for the leaf of *P. biglobosa* (5.99%). Low moisture content of these plants part is an indication that they could have long shelf life against microbial spoilage. *J. gossypifolia* leaf had the highest level of crude protein (21.08%), followed by (11.38%) in *G. arborea* leaf and the least value (3.07%) was recorded in *E. citriodora.* The leaf of *J. gossypifolia* could serve as a source of nitrogen in the body system and could complement protein from other conventional plant foods[20].

The ash content which is an index of minerals in plant was 8.79% in *J. gossypifolia* leaf, followed by 6.01% in *P. biglobosa* leaf while the least value of 4.01% was recorded in the *E. citriodora* seed. Thus, *J. gossypifolia* leaf could concentrate more mineral elements. All the parts studied have low fat content, leaves are generally poor sources of fat and are recommended as part of weight reducing diet, while seeds are known to concentrate oils and could have high oil content. This result is an indication that out of all the samples evaluated, *P. biglobosa leaf* has the highest fat yield. Low fat food could be used nutritionally as a valuable and healthy ingredient to improve poultry health and growth performance. Consumption of low fat foods could imply reduction of cholesterol level in the body system[21].

Table 1: Proximate compositions of different parts of the medicinal plants.

Sample	Part	Moisture Content %	Ash %	Crude fibre %	Crude protein %	Crude fat %	Total carbohydrate %	Nutritive value (kcal/g)
E. camaldulensis	Fruits	7.79±0.33^{a}	4.58±0.20^{c}	9.76±0.42^{b}	5.76±0.62^{c}	6.08±0.00^{c}	66.08±1.3^{j}	344.96^{m}
E. citriodora	Fruits	7.84±0.22^{a}	4.00±0.10^{d}	25.16±0.34^{f}	3.07±0.62^{i}	4.01±0.31^{d}	55.98.±06^{k}	272.29^{n}
G.arborea	Seed	7.79±0.16^{a}	1.92±0.16^{e}	24.14±0.30^{f}	3.50±0.20^{i}	4.12±0.01^{d}	58.54±0.30^{k}	285.25^{n}
	Leaf	8.11±0.04^{a}	5.94±0.23^{c}	13.80±0.36^{g}	11.38±0.10^{g}	5.89±0.29^{c}	54.88±0.23^{k}	318.05^{m}
J. gossypifolia	Seed	7.91±0.21^{a}	5.84±0.55^{c}	9.49±0.36^{b}	10.07±0.62^{b}	4.13±0.27^{d}	62.57±0.78^{i}	327.73^{m}
	Leaf	10.90±0.48^{b}	8.79±0.50^{a}	14.13±0.22^{g}	21.08±0.33^{f}	4.23±0.11^{d}	40.69±0.98^{l}	285.15^{n}
P. biglobosa	Pulp	9.63±0.21^{b}	4.01±0.19^{d}	14.97±0.36^{g}	5.25±0.05^{c}	4.46±0.04^{d}	61.68±0.01^{j}	307.86^{m}
	Leaf	5.99±0.19^{c}	6.01±0.49^{c}	17.38±0.33^{h}	9.63±0.43^{b}	7.48±0.02^{a}	53.15±0.40^{k}	318.44^{m}

Values are mean ± std. deviation of triplicate determinations. Values in the same row with the same superscript are not significantly different

E. citriodora fruits have the highest crude fibre value of 25.16%, followed by *G. arborea* seed with 24.14% while *J. gossypifolia* seed has the lowest value of 9.49%. Physiological role of crude fibre in the diet is for the maintenance of internal dissention for a normal peristaltic movement of the intestinal tract. A diet low in fibre is undesirable, as it could cause constipation and such diets could be associated with diseases of colon like piles, appendicitis and cancer[22]. Therefore *E. citriodora fruits and G. arborea* seed could serve as good sources of fibre diet. Carbohydrate content in *E. camaldulensis* fruits was 66.08%, followed by 62.57% in *Jatropha*. The nutritive value obtained varies between 272.29 kcal/g in *E. citridora* and 344.96 kcal/g in *E. camadulensis*. The plant parts were rich in carbohydrate content and are of good nutritive values. These values compared favourably with a range of 58.9 to 66.20 g/100g reported for some indigenous vegetables[23]. These plants might be a source of energy to vegetarians.

The levels of mineral elements of the samples were reported in Table 2. *P. biglobosa* leaf and pulp, *G. arborea* leaf and seed were found to have the highest values of iron which were 912.90, 839.40, 596.40 and 111.60 mg/100g, respectively. *J. gossypifolia* seeds have the lowest iron content (1.032 mg/100 g). The result is an indication that these plant parts could be a good source of iron which helps in the formation of blood and also in the transfer of oxygen and carbon dioxide from one tissue to another[24]. *G. arborea* leaf contained the highest concentration of copper (58.50 mg/100g), followed by *P. biglobosa* leaf (29.70 mg/100 g), while *J. gossypifolia* leaf had the least value (1.50 mg/100g). Copper is an essential trace metal which must not be excessive in food. The recommended dietary intake of copper is 2 mg, while as little as 10 mg of copper can have a toxic effect. Therefore, these plants could be a good source of copper, although the level in *G. arborea* leaf may have some toxic effects, but not yet reported.

The concentration of manganese was considerably low in the plant parts under study except in *G. arborea seed* and *P. biglobosa* leaf, where the values are 451.50 mg/100g and 264.75 mg/100g, respectively. Manganese is one of the important essential elements required in carbohydrate metabolism as well as an anti-oxidation in superoxide dimultases enzymes. It also plays a role in energy production and supporting the immune system[25]. Low levels of manganese were reported to lead to many health problems including joint pain, arthritis, inflammation and diseases such as Parkinson's, schizophrenia, osteoporosis and epilepsy. Deficiency of manganese could also cause skeletal deformation in animals and inhibit the production of collagen in wound healing[26]. The plants under study could thus serve as a nutraceutical in the prevention of these health problems. The level of magnesium in *E. camaldulensis* fruits was 156.60 mg/100 g, in *E. citriodora* fruits, 166.20 mg/100g and in *J.*

gossypifolia leaf (162.30 mg/100 g) and seed (165.90 mg/100 g). The levels are close to the range of dietary recommendation for magnesium in human which is between 170-355 mg/L[18] and these plants could, therefore, complement other established sources of magnesium. *P. biglobosa* pulp contained 374.70 mg/100g potassium, while *E. citriodora* fruits contained 36.60 mg/100 g. High amount of potassium in the body was reported to increase iron utilization[27] and to be beneficial to people taking diuretics to control hypertension and suffering from excessive excretion of potassium through body fluid[28].

Table 2: Concentration of some mineral elements in different parts of medicinal plants (mg/100g).

Sample	Part	Fe	Cu	Mn	Mg	K	Zn
E. camaldulensis	Fruits	15.60±0.04^{a}	1.80±0.15^{d}	32.40±0.22^{h}	156.60±0.41^{b}	31.20±2.36^{h}	1.80±0.07^{d}
E. citriodora	Fruits	14.40±0.22^{a}	3.30±0.02^{d}	76.20±1.53^{e}	166.20±4.06^{b}	36.60±0.17^{h}	2.70±0.10^{d}
G.arborea	Seed	111.60±5.07^{b}	3.00±0.16^{d}	451.50±4.85^{c}	ND	192.00±0.42^{j}	8.70±0.08^{a}
	Leaf	596.40±7.02^{c}	58.50±4.33^{e}	47.40±0.60^{h}	ND	282.30±2.24^{i}	16.50±0.40^{a}
J.gossypifolia	Seed	1.032±0.01^{d}	2.70±0.11^{d}	11.40±2.20^{a}	165.90±3.46^{b}	ND	13.50±2.65^{a}
	Leaf	78.60±1.30^{e}	1.50±0.15^{d}	10.20±2.20^{a}	162.30±0.14^{b}	ND	9.60±2.20^{a}
P.biglobosa	Pulp	839.40±7.07^{f}	21.90±2.65^{g}	68.70±0.64^{e}	ND	374.70±4.52^{k}	396.00±4.85^{k}
	Leaf	912.90±5.06^{f}	29.70±1.54^{g}	264.75±8.66^{i}	ND	263.70±7.50^{i}	14.70±0.13^{a}

Values are mean ± std. deviation of triplicate determinations. ND = not determined.
Values in the same row with the same subscript are not significantly different.

Zinc was detected in all the samples with its highest concentration observed in *P. biglobosa* pulp (396.00 mg/100 g), while *E. camaldulensis* fruits have the lowest content (1.80mg/100g). Zinc is useful for protein synthesis, normal body development and recovery from illness.[25] The positive impact of zinc supplementation on the growth of some stunted children and on the prevalence of selected childhood diseases, such as diarrhoea, suggests that zinc deficiency is likely to be a significant public health problem, especially in developing countries[29]. According to FAO food balance diet, it has been calculated that about 20 % of the world's population could be at risk of zinc deficiency with its associated symptoms, such as dermatitis, poor wound healing, retarded growth and sexual development and reduced taste acuity. *P. biglobosa* pulp could therefore serve the purpose of supplementing other sources of zinc.

The fatty acid compositions of the samples are presented in Table 3. From the results obtained, it was discovered that the highest level of unsaturation was found in *G. arborea* seed; 42.07% and 45.14% for monounsaturation and polyunsaturation, respectively. The total unsaturated fatty acids can influence the physical properties of membrane, such as fluidity and permeability[30]. Oleic and linoleic acids which are the major constituent of unsaturation in oil are known to be of a great health benefit. Linoleic acid, a polyunsaturated fatty acid which has the chemical formula, cis-9,12-octadecanoic acid [$C_{18:2}$ (9,12)], belongs to omega-6 family. Linoleic acid is indispensable for the healthy growth of human skin[31] . It is essential, because it cannot be synthesized by the body. Linoleic acid is reported to be very crucial to brain development[32]. It can be transformed by the organism into series of long fatty acid chains, such as arachidonic acid, which is a precursor of eicosanoids, necessary to enhance platelet aggregation, vasoconstriction and pro-inflammatory effects[30].

Also, oleic acid is very important in nervous cell constriction. It can be changed by the organism into a set of compounds close to prostaglandins which have an important role at the vessel level and for blood coagulation. Oleic fatty acid has a fundamental role in

cardiovascular disease prevention[31]. The percentage of monounsaturation in *G. arborea* seed could complement other sources of monounsaturated fats; however, the level is low when compared with some established sources of monounsaturated fats which are found in natural foods, such as red meat, whole milk products, nuts and high fat fruits, such as olives and avocados. Olive oil is about 75% monounsaturated fat; sunflower oil contains as much as 85% monounsaturated fat. Canola oil and cashews have about 58% monounsaturated fat contents. Tallow (beef fat) contains about 50% monounsaturated fats and lard contains about 40% monounsaturated fats.

Table 3: Fatty acids (FA) composition of the oils of different parts of the medicinal plants.

Sample	Parts	Saturated FA	Monounsaturated FA	Polyunsaturated FA
E. camaldulensis	Fruits	12.38±0.02^{a}	34.52±0.04^{d}	35.8±0.05^{d}
E. citriodora	Fruits	13.81±0.02^{a}	34.37±0.08^{d}	35.71±0.02^{d}
G. arborea	Seed	18.72±0.04^{b}	42.07±0.07^{e}	45.14±0.06^{e}
	Leaf	19.11±0.01^{b}	17.46±0.04^{b}	18.66±0.01^{b}
J. gossypifolia	Seed	15.07±0.03^{c}	36.26±0.01^{d}	37.50±0.02^{d}
	Leaf	18.74±0.02^{b}	17.82±0.06^{b}	19.44±0.05^{b}
P. biglobosa	Pulp	11.28±0.01^{a}	38.88±0.04^{d}	41.66±0.03^{e}
	Leaf	13.49±0.012^{a}	18.35±0.06^{b}	19.96±0.19^{b}

Values are mean± std. deviation of triplicate determination. FA: Fatty acids.
Values in the same row with the same subscript are not significantly different.

The levels of monounsaturated and polyunsaturated fatty acids, respectively, are 38.88% and 41.66% in *P. biglobosa* pulp, 34.52 % and 35.80 % in *E. camaldulensis* fruits, 34.37% and 35.71 % in *E. citriodora* fruits and 36.26% and 37.50 % in *J. gossypifolia* seed. Percentage of total saturated fatty acids was highest in *G. arborea* leaf; 19.11 % and the least value of 11.28 % was recorded in *P. biglobosa* pulp. Consumption of a high level of saturated fatty acids has been associated to increase blood pressure and could be a risk factor for cardiovascular diseases[33]. However, the levels in the studied medicinal plants are low to be of health concern.

Conclusions

In the present study, eight different edible medicinal plant parts were analyzed for their proximate constituents, metals and fatty acids. It is observed that the nutritional compositions in the studied plant parts could have dietary values which may be used both as medicine and food. Moreover, the natural population should be conserved and their sustainable uses should be developed.

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