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Full Length Research Paper

Investigations on the nutritional and medicinal potentials of *Ceiba pentandra* leaf: A common vegetable in Nigeria

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Ceiba pentandra **is huge, wide, normally found in wild forest of West Africa. The present study investigated the nutritional and bioactive components of the leaf of the popularly consumed vegetable in some part of Nigeria and other West Africa countries. The proximate analysis and bioactive constituents were determined by standard methods of AOAC, while vitamins A, E, micro/macro elements and fatty acids were determined using AAS and HPLC respectively. The results showed that the leaf contained 4.891 ± 0.35% moisture, 12.97 ± 1.60% protein, 52.06 ± 2.10% carbohydrate, 4.35 ± 0.60% fat, 7.54 ± 0.46% ash, 18.15 ± 0.05% crude fiber, 0.73 ± 0.07 µg/g vitamin A, 4.91 ± 0.16 mg/g vitamin C and 0.18 ± 0.02 mg/g vitamin E while micro/macro elements and fatty acids showed that the leaf contained 0.33 ± 0.05, 7.66 ± 1.40, 2.46 ± 0.46, 11.40 ± 2.10, 5.53 ± 0.95, 0.02 ± 0.04, 0.03 ± 0.01 and 0.04 ± 0.02 mg/100 g of Fe, Ca, Mg, K, Na, Cu and Zn respectively. 15.92 ± 0.17% palmitic acid and 0.72 ± 0.02% linolelic acid. The bioactive compound found were 173.94 ± 3.09 mg/g phenolics, 4.54 ± 0.02 mg/g alkaloids, 26.06 ± 0.16 mg/g flavonoids, 0.48 ± 0.03 mg/g tannins, 1.55 ± 0.04 mg/g saponnins, 0.15 ± 0.02 mg/g phytate, 14.54 ± 0.50 TUI units/mg trypsin inhitors, 9.65 ± 1.28 HUI unit/mg hemagglutinin inhibitors. All these results indicate that the leaves of this *C. pentandra* contained nutrients and mineral elements that may be useful in nutrition, while the bioactive compounds explained the medicinal action of the plant leaves encountered in its therapeutic uses and or which provide scientific basis for its use in folk medicine.**

Key words: *Ceiba pentandra*, nutritional, medicinal potentials and proximate.

INTRODUCTION

Ceiba pentandra is a plant that is normally found in the wild, it belongs to the family of Bombacaceae. The matured tree is as much as 56 m high by 10 m or more in girth, with long cylindrical and huge buttresses to 8 m high and wide spreading. It is the largest tree of the West Africa region and occurs throughout, is a multipurpose plant that is well known in practice by the farmers of Cambodia and traditionally used in goat production (Theng et al., 2003b). There are some varieties which spontaneously shed pods by bursting. The English name, cotton tree or silk cotton tree, is derived from the floss and is a universal trade name. Various part of the plant are essential, used for various illness as laxative, as foliage for goat, trunk for domestic plank and wood pulp for paper (Daziel and Hutchchinson, 1956). The bark contains a blackish mucilaginous gum which swells in water and resembles trasgacanth; it is astringent and is used in India and Malaya for bowel- complaint and West Africa for diarrhoea (Burkill, 1985). It is also used for skin medicine on skin-infection, used for tooth-troubles in Senegal (Bouquet and Debray, 1974).

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In Nigeria the leaves are cooked in form of slurry sauce, comparable to okra. The leaves are used as an alterative and laxative and the infusion is given as a cure for colic in man and in livestock (Burkill, 1985). In Kano, Nigeria it is used for curative dressing on sores, for maturate tumors in Guinea, whitlows in Congo and massage with leaf-pulp and baths in bark-decoction are considered excellent for evening fever especially those deemed to arise from evil influence (Daziel and Hutchchinson, 1956) . The flower is used in Guinea for constipation and for gonorrhea in West Africa. The young leaf are sometimes cooked and eaten in West Africa as a soup herb (Burkill, 1985). The mature leaves contain mucilage which can be obtained by boiling and is used to remove foreign bodies from the eye in Ivory Coast, emollient and sedative in Garbon (Burkill, 2000) leaf sap is given in draught to mental cases.

In Senegal freshly pounded leaves are steeped in water which is drunk for general fatigue and lumbago. In many countries in Africa, the bark and the stem is taken for diarrhoea, localized oedemas, wash sores, furuncles, leprous macules, relieve stomach complaints, hernia, blennorrhoea, heart-trouble, asthma, gargles for gingivitis, aphtes and sometimes toothache (Burkill,1985). In Nigeria the bark infusion is used for febrifuge (Burkill, 2000). A bark-decoction is given to rickety children, bark sap is given to sterile women to promote conception by reason of the fecundity of the seed in Ivory Coast- upper (Burkill, 2000). The seed contains oil used as vegetable in some part of the country. It also contains fatty acids glycosides, saponins and steroids (Sarkiyayi et al., 2009).

In Isanlu, Kogi State, Nigeria, the stem of the old matured plant are cut and propagated at the back of the house. The young leaves or the shoots are normally used for soup (sausage). Thus, sauce is found suitable for easy consumption of starchy balls made from cassava, yam or millet, pounded yam etc. A powder prepared from dried leaves is used to prepare sauce during the dry season. Despite all its nutritional and medicinal potentials, there is scanty information on the bioactive compounds, anti-nutrients, micronutrients and fatty acids composition of this plant leaf. Therefore, these studies were undertaken to provide to examine the bioactive component, nutritional value/ant- nutrition's and fatty acid profiles in furtherance to ascertain the nutritional and medicinal potentials of the plant leaf.

MATERIALS AND METHODS

Collection of plant sample and identification

The tender *C. pentandra* leaves were collected from the *C. pentandra* planted two years ago at the farm located in the staff Quarter, Kogi State University, Anyigba, Nigeria. The leaf was identified and authenticated by Mr Patrick, a taxonomist in the Department of Biological Sciences (Botany option), Faculty of Natural Sciences, Kogi State University, Anyigba Nigeria.

Sample preparation

Collected plant leaves were cleaned and spread on the already cleaned laboratory bench for two weeks in the Biochemistry Department, Kogi State University. The dried leaf was pounded into powder with laboratory mortar and pestle. A portion (50 g) of the powdered sample was processed for various parameters according to the following procedures:

Proximate analysis

The proximate analysis (carbohydrates, fats, protein, moisture and ash) of the plant leaf were determined by the method described by AOAC, 1990. Carbohydrate was determined by subtraction difference methods (100 – (crude protein + crude fats + crude fiber + moisture + ash)). The total crude protein was determined by micro Kjeldahl method. The nitrogen" value was converted to protein by multiplying a factor of 6.25. The "moisture and ash" were determined using weight difference method while determination of crude lipid content was done using Soxhlet type of the direct solvent extract method. The solvent used was petroleum ether (40 to 60°C) analar grade (Muhammed et al., 2010).

Elemental analysis

The sample was investigated for element composition by using atomic absorption spectrophotometer (AAS), bulk scientific model AVG 210. Appropriate working standard solution was prepared for each element. The calibration curves were obtained for concentration versus absorbance. The data were statistically analyzed by using fitting of straight line by least square method. All elements were determined in the medicinal plant (*C. pentandra*) under this investigation procedure. Laboratory procedures for the preparation and determination of macro and micro nutrients were used as outlined by Shah et al. (2009) for plant samples.

Vitamin A, E and fatty acid profile determination

Higher performance liquid chromatography was used to determined fatty acid profile, vitamin (V) A and E content.

Preparation of sample for HPLC

A portion (0.50 g) of sample was weighted into 10 ml capped bottle and 10 ml of N-hexane (BDH, HPLC grade) was added and shacked to dissolve and left to stay overnight. The content was then centrifuged and the supernatant (hexane layer containing the extracted oil) removed with pipette and kept for (V) A, E and fatty acids analysis by HPLC.

For vitamin A and E

A portion (2 ml) of the aforementioned extract was measured into test tube and hexane was evaporated through nitrogen gas. A portion (2 ml) of methanol (HPLC grade) was added to dissolve the vitamins (fat soluble). A portion (20 l) of it was injected into HPLC (AKPA HPLC) with column ODS 2 C_{18}, detector: UV 290 nm and F/R = 10 l/min.

For fatty acid

A portion (2 ml) of the aforementioned extract measured into a test

Table 1. Proximate composition of *Ceiba pentandra* leaf.

Moisture content (%)	Protein (%)	Carbohydrate (%)	Fat (%)	Ash (%)	Crude fiber (%)	Vitamins content		
						A (g/g)	C (mg/g)	E (mg/g)
4.89 ± 0.35	12.97 ± 1.60	52.06 ± 2.10	4.35 ± 0.60	7.54 ± 0.46	18.15 ± 0.05	0.73 ± 0.07	4.91 ± 0.16	0.18 ± 0.02

Values are expressed as mean ± S.D (n = 3).

Table 2. Macro and Micro Element composition of *Ceiba pentandra* leaf.

Fe	Ca	Mg (mg/100 g)	K	Na	Mn	Cu	Zn
0.35 ± 0.50	7.66 ± 1.40	2.46 ± 0.46	11.40 ± 2.10	5.53 ± 0.95	0.02 ± 0.01	0.03 ± 0.01	0.04 ± 0.02

Values are expressed as mean ± S.D (n = 3).

tube and 0.3 ml of 1 M Na- methoxide, it was mixed thoroughly and left overnight and centrifuge. The clear solution decanted and evaporated to dryness. A portion (2.0 ml) of "acetonitrile" (BDH and HPLC grade) was added and shakes to dissolve the precipitate. Then 20 l was injected into the HPLC with column ODS 2 (C_{18}), detector UV 215 nm and F/R = 1 /min (Nikolova, 1997). The "fatty acids", vitamin A and E was calculated with reference to the standard using this formula:

$$\text{Conc.} = \frac{\text{Peak area (in AU mi) of sample}}{\text{Peak area (in AU min) of standard}} \times \text{Conc. of standard of sample}$$

Vitamin C determination

The determination of Vitamin C content of the *C. pentandra* leaf was described by AOAC (1990).

Phytochemical analysis

Total phenolics were determined by method described by Mole and Waterman (1987), flavonoids by aluminum chloride colorimetric method described by Chang et al. (2002), saponnins by the spectrophometric method of Brunner as described by Akinmutimi (2006), alkanoids by gravimetric method of Harbone as described by Onwuka (2005), tannins was determined by method of Maga as described by Akinmutimi (2006) and Phytate by Lucus and Markakas method as described by Akinmutimi (2006).

Statistical analysis

All data were expressed as mean ± SD and GraphPad Instat (Data set 1.SD) were used.

RESULTS

The proximate composition and vitamins of young leaf of *C. pentandra* are summarized in Table 1. While Table 2 shows micro and macro mineral elements. The results show the concentration of element in the highest order in the mg/100 g of plant leaf of 11.40, 7.66, 5.53, 2.53, 2.46, 0.35, 0.04, 0.03 and 0.02 in K, Ca, Na, Mg, Fe, Zn, Cu and Mn respectively. The Table 3 shows the result of bioactive component of the *C. pentandra*. The results showed that the young leaf of *C. pentandra* has 173.94 ± 3.09 mg phenolics, 4.54 ± 0.20 mg alkaloids, 26.06 ± 0.16 mg flavonoid and 1.55 ± 0.04 mg saponnin per gram of the sample. The average contents of the fatty acids in *C. pentandra* leaf are presented in Table 4.

DISCUSSION

Nutritional composition

Green vegetable are generally acceptable as good source of nutrients and supplement for staple food in a World faced with problem of food scarcity. They have known to be excellent source of nutrients such as mineral and vitamins. The moisture content of *C. pentandra* as showed in Table 1 was very high although within the range of moisture content for fruits and vegetables of 60 to 83 g/100 g (FAO, 1968). However the high moisture content may underscore its high perishability and susceptibility to microbial infection (Tressler et al., 1980). The high moisture content makes to aid the digestion of food. The values of carbohydrate > crude fiber > protein > ash > crude fat obtained were higher in this order. Fiber is useful for maintaining bulk, motility and increasing intestinal peristalsis by surface extension of the food in the intestinal tract (Mathenge, 1997). It is necessary for health condition curing nutrition disordered and for food digestion.

The young leaf of *C. pentandra* is extremely high in

Table 3. Bioactive constituents of *Ceiba pentandra* leaf.

n = 3 ± SD. Phen = total phenolic, Alk = alkanoid, Fla = flavonoid, Tan = tannin, Sap= saponnin, CN = cyanide, Phy = phytate, TUI = trypsin inhibitor, HUI = hemagglutinin inhibitor and Oxal = oxalate.

Table 4. Fatty acids composition of *Ceiba pentandra* leaf.

Lauric acid (%)	Myristic acid (%)	Palmitic acid (%)	Oleic acid (%)	Linolelic acid (%)	Stearic acid (%)
ND	ND	15.92 ± 0.17	ND	0.72 ± 0.02	ND

Values are expressed as mean ± S.D (n = 3), ND = not detected

fiber content as revealed by this result. This was indicative of its high soluble fiber (pectin) (Oladejo, 2009). Soluble dietary fibers have health-promoting properties as they have been implicated in lowering plasma and liver chlolesterol concentration (Behall, 1986) diarrhea treatment and detoxification of poisonous metals (Cohn and Cohn, 1996). The high value of carbohydrate and protein suggest its nutritional quality of the *C. pentandra* leaf and this may be a veritable tool been used by the villagers for source of body nourishment. The moderate high value of the ash content is an indicative of high mineral value especially the macro minerals in the young leaf of *C. pentandra*. The value obtained was close to that of some leaf vegetables commonly consumed in Nigeria such as *Talinum triangulare* (20.50%) however higher than *Occimum graticukum* (8%), *Hibiscus esculentus* (8.00%) (Akindahunsi and Salawu, 2005) . The crude fat value is moderate as compared to those of *T. triangulare* (5.90%), *Amaranthus hybridus* (4.80%), *Calchorus africanum* (4.20%) (Akinhunsi and Salawu, 2005).

Dietary fats function in increase of palatability of food by aborbing and retaining flavours (Antia et al., 2006). A diet providing 1 to 2% its caloric of energy as fat is said to be sufficient to human beings as excess fat consumption is implicated in certain, cardiovascular disorder such as atherosclerosis, cancer and aging (Antia et al., 2006). The results of selected vitamins composition of the young leaf of *C. pentandra* are shown in Table 1. The reasonable values obtained for vitamin A, C and E suggest that the plant may be of help in solving or reducing the prevailing micronutrient deficiency diseases ramphaging poor shrinking community especially Sub-Sahara Africa such as blindness, cancer, heart diseases etc. Tocopherol (vitamin E), ascorbic acid (VC) and carotenoids (pre- cursor of vitamin A) are anti-oxidants which have been associated with prevention of nutritional related diseases such as cancer, diabetes mellitus, coronary heart diseases and obesity. (McDougall et al., 1996; Larrauri et al., 1996). Ascorbic acid is essential for the healthy formation of bones and teeth. It is powerful anti-oxidant (Szeto et al., 2002) whose deficiency results in scurvy with swelling of the joints and gums, loosening of the teeth and hemorrhage of the skin and mucous membrane. Evidence of vitamin C playing a key role in decreasing the incidence of degenerative diseases is considered to be strong (Halliwell, 1996).

Low ascorbic levels have been associated with fatigue and increased severity of respiratory tract infections (Johnston et al., 1998), while high intake of vitamin C from food had been shown to raise serum HDL-Cholesterol and lower serum trigly ceride concentration (Ness et al., 1996), hence this young leaf of *C. pentandra* have these health promoting potentials.

Macro and micro elements

Nutritional experts and medical doctors now recognize and are emphasizing the important roles of mineral and trace elements to human health and well being (Tolonen, 1990). It is estimated that 70 biological trace elements are needed by all living things for the normal function of their metabolism, reproductive and immune system. (Obiajunwa et al., 2005). The selected macro/micro elements found in *C. pentendra* are shown in Table 2. These results showed that *C. pentandra* leaf is rich in essential minerals and trace elements that promote well being in humans. Iron and “copper” for example are essential in blood formation and copper is also involve in normal carbohydrate and lipid metabolism, and zinc for its part is a multifunctional nutrient involved in glucose and lipid metabolism, hormone function and wound healing (Obiajunwa et al., 2005) and is also associated with proper hair growth (Wang et al., 1985).

Magnesium is important for any biochemical process in an organism, promotes balancing of minerals, and it is necessary for normal job of muscles, and nervous (Okaka et al., 2001), system, activity of hormones, manufacture of energy maintenance of health of

reproductive system, immune system and regulation of an intimate rhythm and arterial pressure together with calcium (Eryomenko, 2010). Calcium is important in health and muscle metabolism (Turan et al., 2003). According to Shill and Yong (1988), good food calcium content is greater than one and poor if less than 0.5. From the result, this implies that *C. pentandra* is a good source of calcium.

Copper aids in the formation of bones, conversion of iron into hemoglobin and works with zinc and vitamin C for the production of elastrin. It is also necessary for the production of RNA, phospholipids, protein metabolism and ATP, help to convert tyrosine into pigment that color the skin and hair, it is also involved in the healing process, taste, healthy nervous and formation of collagen, it is also reported that copper imbalance raises cholesterol by destroying proper HDL to LDL balance. Manganese serve as cofactor in many enzyme systems including those involving in bone formation, energy production, and metabolism of protein, carbohydrate and fat. It is required for choline acetylcholine transfer, enhances smooth muscle relaxation, and promotes normal growth and development and cell function.

Sodium and potassium are important for chemical reaction within the cells and regulates the transfer of nutrients to the cells. Sodium works in conjunction with potassium for extracellular fluid balances (Okaka et al., 2001). As can be seen in the results, daily consumption of this leaf can add values to recommended dietary allowance (RDA) of mineral element thereby improving health and well being.

Bioactive compounds

The present research has provided first hand information on bioactive and anti-nutrient constituent studies on young leaf of *C. pentandra*. The bioactive component studied revealed that *C. pentandra* has substantial amount of phenolics compound, alkanoid, flavonoid, tannin, sponnin, phytate, oxalate, trypsin inhibitor and hemagglutinin. These bioactive compounds (flavonoid, alkaloids, phenolics and saponnins) are known to exhibit medicinal activity as well as physiological activity (Sofomora, 1993). Flavonoids have been shown to have anti-mutagenic, antibacterial, anti-inflammatory, antiallergic, antiviral, anti-neoplastic, anti-thrombotic and vasodilatory activity (Alan and Miller, 1996).

The potent anti-oxidant activity of flavoniods is their ability to scavenge hydroxyl radicals superoxide anions and lipids peroxy radicals and may be the most important function of flavoniods (Alan and Miller, 1996) . Various studies have shown that saponnin although non toxic can generate adverse physiological responses in animals that consume them, they exhibit cytotoxic effect and growth inhibition against a variety of cell making them have anti-inflammatory and anticancer properties (Iniaghe, 2009). They also show tumor inhibiting activity on animals (Akindahunsi and Salawu, 2005). The presence of saponnins from various studies indicate their importance and interest in pharmacy due to their relationship with such compounds such as sex hormones especially in development of the female contraceptive pill (Edeoga et al., 2006) . This may be the reason why the infusion of the leaves of *C. pentandra* is given to expectant mothers in Guinea to ensure hormonal balance. Phenolics compounds are class of antioxidant agents which act as free radical terminators (Shahidi and Wanasundara, 1992).

Polyphenols constitute the main bioactive phytochemicals that have been proven to be effective in the prevention of certain chronic diseases such as coronary heart diseases, cancers and diabetes (Asami et al., 2003). Tannins are fairly frequently encountered in food products of plant vegetable origin such as tea and many fruits. The oxidation inhibition activity of tannins have been known for a long time and it is assumed to be due to the presence of gallic and digallic (Ihekoronye and Ngody, 1985). The result of those bioactive constituent in the *C. pentandra* further suggest the reason for usage of the plant to cure many diseases such as colic in man, dressing on sores for maturate tumours, whitlow, inflammatory, cancer, mental illness, fatigue, lumbago, gonorrhoea, dysentery, ant-microbial and anti-fungal effect (Edeoga et al., 2006). The anti-nutrient content (cyanogenic glycoside, trypsin inhibitors, hemagglutinin inhibitor, phytate and oxalate as shown in Table 1 shows that the plant has low content value of various anti-nutrients determined. This implies that the plant leaf is very safe and good for human health.

This finding corroborates the report of Sarkiyayi et al. (2009) on the acute and chronic toxicity profile studies of *C. pentandra* which showed that in all the parameters studied (AST, ALT, ALP, serum bilirubin, PCV and creatinine) were within physiological acceptable range, therefore, the plant leaf is relatively safe for herbal oral medication.

Fatty acids composition

As shown in Table 4, the most abundant fatty acid found was palmitic Acid (c) followed by linolenic acid ($C_{18.2}$) other (lauric, myrustic, oleic and stearic were not detected in the sample. However, the values obtained were close or higher compared to other vegetables only reported for example spinach 16.3% (C_{18}). *Asparagus* 46.8% ($C_{18.2}$), 25.6 ($C_{16.0}$) letuce 20.2% ($C_{18.2}$), brocoli 16.9% ($C_{18.2}$), 25.0% ($C_{16.0}$) (Vidrih et al., 2009). For the fact that the sample contain substantial amount of linolenic acid, thus indicate good nutritional qualities, because the linolenic acid is part of the n–3 series and it is known to be present in many plants (Lious et al., 2002), along with C_{16}:3n–3 in some plant species

(Mongrand et al., 1998) -linolenic acid can also act as a precursor acid of long chain PUFAs. Although -linolenic acid had has been shown to increase the synthesis of long chain PUFAs (Lious et al., 2007).

According to Indu and Ghafoorunissa (1992), high long term intake of -linolenic acid provide only modest benefit compared to fish oils. It has also been shown that supplementation of high doses of -linolenic acid in form of linseed oil, produced antiggregatory effects (Budowski, 1988). A high doses of linolenic and have been linked to a possible increased risk for prostrate cancer or muscular degeneration. Epidemiologic report indicate that both polyunsaturated fatty acids (PUFA) and vegetables can protect from cardiovascular diseases (CVD), but concern has arisen that the unbalance between dietary PUFA and bioactive vegetable compounds may lead to oxidative stress (Misikangas et al., 2001). -linolenic acid is one of the omega 3 fatty acids, omega - 3 fatty acid reported to reduce inflammation.

The positional distribution of fatty acids in dietary triglycerides, as well as the fatty acid composition, is important factor of fat digestion and absorption (Murphy and Signer, 1974). Triglycerides in human breast milk contain appropriately 20 to 25% palmitic acid ($C_{16.0}$) with over 70% of the ($C_{16.0}$) esterifies to the Sn-2 positioning the milk triglyceride (Martin et al., 1993). The specific positioning of ($C_{16.0}$) at the 2–position of human breast milk triglycerides has been suggested a one of the reasons for high efficiency of fat absorption from human milk and calcium. Therefore, it has been discussed to humanize the fat source stereospecifically by fortifying with Sn–2 palmitic acid in the infant formula to increase absorption rate of lipids and calcium (Lious et al., 2007).

Conclusion

In the light of this investigation, *C. pentandra* has been found to contain some nutrients and phytochemicals and this supports its ethno medicinal uses and therefore a good source of nutrients and medicine that require special attention for development.

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