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Evaluation of the Chemical Composition, Nutritive Value and Antinutrients of *Terminalia catappa* L. Fruit (Tropical Almond)

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***Abstract*— *Terminalia catappa* L. fruits were analyzed to establish their chemical composition and nutritive properties in order to investigate the possibility of promoting their usage as human food or animal feed. The seeds (enclosed in the hard stone-like core) and the pulp (succulent exocarp and fleshy fibrous mesocarp) were analyzed. Proximate analyses showed that the seeds and pulp contained 47.34±0.03% and 80.93±0.05% moisture, 28.70±0.59% and 8.75±0.01% crude protein, 5.19±0.08% and 4.79±0.17% ash, 3.76±0.34% and 3.10±0.03% crude fibre, 44.64±0.11% and 0.51±0.02% fat, 17.71±1.12% and 82.85±0.23% carbohydrate and 587.40±7.28kcal and 370.99±1.14kcal of energy, respectively. Percentage organic matter was higher in the pulp than in the seed (95.21% and 94.81%, respectively). The seed was found to be a good source of phosphorus (44.367±0.025mg/100g) as the highest value, followed in descending order by magnesium (33.286±0.110mg/100g), potassium (30.355±0.082mg/100g), sodium (26.845±0.072mg/100g) , zinc (25.952±0.038mg/100g), calcium (20.134±0.007mg/100g) and iron (0.023±0.001mg/100g). In the pulp, phosphorus was also found to be the highest mineral with a value of 22.566±0.012mg/100g. Other minerals were present in trace quantities in the pulp. The pulp was found to be rich in vitamin C (797.95±0.11mg/100g). Vitamin A was low in the seed (0.13±0.02mg/100g) and pulp (0.38±0.03mg/100g). These fruits were seen to contain antinutrients mostly in the pulp. Oxalate was the most abundant (205.123±0.021 and 396.645±0.017mg/100g) in the seed and pulp, respectively while the least, phytic acid was 2.065±0.033 mg/100g (seed) and 4.675±0.014mg/100g (pulp). The fruit should be eaten by all as it is seen to be rich in nutrients.**

***Index Terms*— Antinutrients, Minerals, Nutrients, Proximate analyses, *Terminalia catappa* L., Vitamins.**

I. INTRODUCTION

Terminalia catappa L. is a tropical tree of the Combretaceae family encountered in many tropical regions [1]. *Terminalia catappa* L. grows, reaching heights of 20-45m and shows strong salt-, drought- and wind-tolerance. It produces fruits (3-7cm long) with a thin flesh surrounding a large fibrous nut which encloses the seed [2]. The fruit of *Terminalia catappa* L. is classified as a drupe (fleshy mesocarp and stone-like stiffened endocarp, where the seed is). The plant is believed to have originated in Malaysia [3]. *Terminalia catappa* is native to tropical Asia. It was introduced to Cote d'Ivoire during colonization for urban ornamentation [4].

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Terminalia catappa L. is a large, deciduous tree (Plate 1.0) with smooth grey bark and whorled branches that form a canopy and is found in tropical and subtropical regions. The fruit is large (1.2-2.3"), edible, fleshy, green (unripe) and yellow or red (when ripe) containing a single seed. The fruit has a husk (34.08%), a porous and fibrous pericarp (8.97%), an exocarp which is relatively thin and smooth while the hard endocarp (46.63%) encloses an edible kernel (10.32%) [5].

Plate 1.0: Photograph of a *Terminalia catappa* L. tree.

Botanically, tropical almond is not a nut but a fruit [6] and can be classified thus:

Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division : Magnoliophyta
Class: Magnoliopsida Subclass: Rosidae
Order: Myrtales
Family: Combretaceae
Genus: Terminalia L.
Species: *Terminalia catappa* L.

The common vernacular names include castanhola (Brazil), miich (Palanan), bedan (Yemeni) and ebelebo (Nigeria) amongst others [7]. *Terminalia catappa* L. contains hydrolyzable tannins, flavonoids and triterpenoids [8] which are the active constituents of the fruit.

Traditionally, the leaves, fruits and bark of *Terminalia catappa* L. have several uses [9]. It is considered to have aphrodisiac and antibacterial properties and it is thought to be useful in the treatment of certain forms of sexual inadequacies such as premature ejaculation [10]. *Terminalia catappa* L. is known to have antioxidant, antidiabetic, anticancer, antiviral, antifungal and antimicrobial, anti-inflammatory, analgesic, aphrodisiac and anti-sickling of human 'SS' erythrocytes activities. The fruit shell of *Terminalia catappa* L. has proved

to be useful precursor material for the preparation of carbon adsorbent used in the removal of Hg (II) from aqueous solutions [11].

The fruit of *Terminalia catappa* L. is known to attract fruit flies. Stands of tropical almond appear to be somewhat isolated from other known hosts of oriental fruit fly but the fruit infestation levels suggest that this tree may contain a powerful attractant for female oriental fruit flies.

The sole aim of nutritionist, food scientist and biochemist is to explore the various sources in which the different nutrients could be obtained especially from sources which abound in our immediate environment. This has led to various researches, to determine the various compositions of sampled fruits which are less commonly eaten in our society. One of such fruits is the fruits of *Terminalia catappa* L.

The research work is aimed at analyzing the fruit (pulp and seed) of *Terminalia catappa* L. to establish their chemical compositions and nutritive values in order to investigate the possibility of promoting their usage as food for humans or feed for animal consumption.

II. MATERIALS AND METHODS

A. Collection and Sample Treatment

The seeds and pulp was obtained from ripe fruits of *Terminalia catappa* L. located in the University of Uyo, Town campus, Uyo, Akwa Ibom State, Nigeria. About fifty ripe fruits were collected and taken to the University of Uyo herbarium for proper identification of the variety. The succulent portion of the fruit was scrapped off from the hard core nut using a knife to obtain the pulp. The hard core nut was broken using a hammer to obtain the seeds.

B. Proximate Analysis

Proximate analyses carried out on the samples included moisture, crude protein, crude fat, fibre, ash and carbohydrate contents. This was done following the method of [12]. Carbohydrate content of the samples were obtained after subtracting values of crude protein, crude fat, crude fibre and ash content from 100%.

Carbohydrate = 100 – (a+b+c+d), where a = crude protein, b = crude fat, c = crude fibre, d = ash content. Organic matter was obtained by subtracting the ash content from 100. i.e Organic matter = 100 - %Ash. The caloric value was obtained by multiplying the values of the protein, lipid and carbohydrate by 4kcal, 9kcal and 4kcal respectively and taking the sum of its products obtained. i.e. Caloric value = (protein x 4kcal) + (lipid x 9kcal) + (carbohydrate x 4kcal).

C. Determination of Mineral elements composition

Ca, Mg, Fe and Zn were estimated by atomic absorption spectrophotometry (AAS) method of [13]. Na and K were estimated following flame photometric method of [14]. Phosphorus was estimated following [15] method of analyses.

D. Determination of Antinutrients composition

HCN was estimated following the method of [12]. Oxalate estimation was done following the method of [16]. Phytic acid was estimated following the method of [12]. Tannin was estimated following the method of [17].

E. Determination of Vitamins composition

Vitamins A and C were estimated following the method of [12].

III. RESULTS AND DISCUSSION

A. Proximate Analyses

The results of the estimation of the moisture, ash, crude protein, crude fibre, crude fat and carbohydrate contents of *Terminalia catappa* L. are presented in Table 1.

TABLE I
PROXIMATE ANALYSES OF NUTRIENTS IN *Terminalia catappa* L. FRUITS

PROXIMATE COMPOSITION	MEAN ± STANDARD DEVIATION	
	SEED (%)	PULP (%)
Crude fat	44.64±0.11	0.51±0.02
Crude protein	28.70±0.59	8.75±0.01
Crude fibre	3.76±0.34	3.10±0.03
Total ash	5.19±0.08	4.79±0.17
Carbohydrate	17.71±1.12	82.85±0.23
Moisture	47.34±0.03	80.93±0.05

Values are mean ± standard deviation of triplicate determinations

The moisture content is given in terms of % wet weight of the samples. The moisture present in the pulp is almost double that in the seed. This is mainly because the fresh pulp is more succulent than the seed. The moisture content of food usually serves as an index of stability and susceptibility to microbial infection [18]. Hence, the higher the moisture level, the shorter the shelf life and vice versa.

The ash content was found to be slightly higher in seeds (5.19±0.08%) compared to the pulp (4.79±0.17%). The seeds contained more of crude protein (28.70±0.59) than the pulp (8.75±0.01). Proteins serve as component of nuclear and cytoplasmic structure that takes part in maintaining cellular organization, including full component of enzymes involved in metabolism during maturation and growth [19]. The crude fibre contents of seeds and pulp were approximately the same (3.76±0.34% and 3.10±0.03%, respectively). Fibre consists largely of cellulose together with lignin and hemicelluloses [20]. Dietary fibres have been reported to have beneficial effects on muscles of intestine during peristalsis [21]. Fibre is not digested by man but provides roughages that aid digestion [22]. Fibre is a rich source of silicon (element found in the connective tissues and arterial walls).

Crude fat is richly abundant in the seed (44.64±0.11%) and merely present in the pulp (0.51±0.02%). Fats are vital for structural, biological functions in the cell and dissolution of nutritionally essential fat-soluble vitamins (vitamins A, D, E & K).

The pulp contains higher quantities of carbohydrate (82.85±0.23%) than the seed (17.71±1.12%). Carbohydrates are the significant sources of energy for cellular metabolism. It can also perform functional and structural roles in the animal body.

The results of the organic matter and measure of the energy content in the seeds and pulp of *Terminalia catappa* L. are presented in Table II.

TABLE II
ORGANIC MATTER AND CALORIC VALUE IN *Terminalia catappa* L. FRUITS

Parameter	MEAN ± STANDARD DEVIATION	
	SEED	PULP
Organic matter	94.81±0.002%	95.21±0.06%
Caloric value	587.80±7.28 kcal	370.99±1.14 kcal

Values are mean ± standard deviation of triplicate determinations

The result shows that the seed has a higher caloric value than the pulp i.e the seed has more energy value than the pulp. The organic matter in the seed and pulp is approximately the same.

B. Mineral elements composition

The results of the estimation of the mineral elements (Ca, K, Na, P, Fe, Zn and Mg) in *Terminalia catappa* L. fruits (seed and pulp) are presented in Table III.

TABLE III
MINERAL ELEMENTS COMPOSITION IN *Terminalia catappa* L. FRUITS

MINERAL COMPOSITION	SYMBOLS	MEAN ± STANDARD DEVIATION	
		SEED (mg/100g)	PULP (mg/100g)
Calcium	Ca	20.134±0.007	1.193±0.025
Potassium	K	30.355±0.082	2.288±0.092
Sodium	Na	26.845±0.072	1.952±0.074
Phosphorus	P	44.367±0.025	22.566±0.012
Iron	Fe	0.023±0.001	0.001±0.000
Zinc	Zn	25.952±0.038	0.163±0.019
Magnesium	Mg	33.286±0.110	1.264±0.054

Values are mean ± standard deviation of triplicate determinations

Mineral element analyses reveal that the seed contain more proportion of minerals compared to the pulp of the fruit. Phosphorus was the highest (44.367±0.025mg/100g) in seed and (22.566±0.012mg/100g) in the pulp of the fruits. For the seed of *Terminalia catappa* L., the level of elements were as follows P > Mg> K> Na > Zn > Ca> Fe with values 44.367±0.025, 33.286±0.110, 30.355±0.082, 26.845±0.072, 25.952±0.038, 20.134±0.007 and 0.023±0.001mg/100g, respectively.

For the pulp, the level of elements were as follows P > K> Na> Ca> Mg > Zn> Fe with values 22.566±0.012, 2.288±0.092, 1.952± 0.074, 1.193±0.025, 1.264±0.054, 0.163±0.019 and 0.001±0.000mg/100g, respectively. Fe was observed to be the least amount in both seed and pulp with values of 0.023±0.001mg/100g and 0.001±0.000mg/100g of dry matter of seed and pulp, respectively. For the whole fruit, the level of the element were found to be P > Mg> K> Na > Zn > Ca> Fe.

C. Antinutrients composition

Antinutrients are natural or synthetic compounds that interfere with the absorption of nutrients [23]. Table IV. presents the results of the antinutrients composition of *Terminalia catappa* L. fruits (seeds and pulp)

TABLE IV
ANTINUTRIENTS OR TOXICANTS COMPOSITION IN *Terminalia catappa* L. FRUITS

TOXICANT COMPOSITION	MEAN ± STANDARD DEVIATION	
	SEED (mg/100g)	PULP (mg/100g)
Hydrocyanic acid (HCN)	6.035±0.012	7.344±0.025
Oxalate	205.123±0.021	396.645±0.017
Phytic acid	2.065±0.033	4.675±0.014
Tannin	35.000±0.006	44.000±0.003

Values are mean ± standard deviation of triplicate determinations

The pulp of *Terminalia catappa* L. fruits contains higher quantity of HCN (7.344±0.025mg/100g) compared to the seed (6.035±0.012mg/100g). It is the presence of this HCN that gives the tropical almond its characteristic taste. Depending on its dosage, the fruit can be toxic as the cyanide ions are known to arrest electron flow in the electron transport chain at $Cytaa_3$ (complex IV) [24].

Oxalate is the most prevalent antinutrient present in the fruit of *Terminalia catappa* L. Oxalate is very high in the pulp than in the seed (396.645±0.017mg/100g and 205.123±0.021mg/100g, respectively). Oxalic acid is an antinutrient that inhibits the absorption and utilization of calcium by precipitating it to form insoluble calcium oxalate. Oxalate also forms insoluble complexes with Mg, Zn and Hg [25].

The *Terminalia catappa* L. fruit contains higher quantity of phytate in the pulp than in the seed (4.675±0.014mg/100g and 2.065±0.033mg/100g, respectively). Phytic acid is an antinutrient that is known to cause deficiency of Ca and Fe due to the formation of insoluble phytates. When present in large amount, they act as a major inhibitor of iron absorption. Phytate have been reported to reduce growth and feed intake when fed in large amounts [26].

Tannin is the second most abundant toxicant in *Terminalia catappa* L. fruit. Its level is higher in the pulp than in the seed. Tannin is known to bind irreversibly to proteins, rendering it indigestible by intestinal enzymes. Tannins such as catachin are found in the leaves of *Terminalia catappa* L. thus explaining its characteristic therapeutic application. This antinutrient also have its beneficial role i.e. it can diminish perspiration and cause relieve to asthmatic patients [27]. Generally, the pulp is seen to contain a higher quantity of the antinutrients than the seed.

D. Vitamins composition

The result of the estimation is presented in Table V.

TABLE V
VITAMINS COMPOSITION IN *Terminalia catappa* L. FRUITS

VITAMIN COMPOSITION	MEAN ± STANDARD DEVIATION	
	SEED (mg/100g)	PULP (mg/100g)
Vitamin A	0.13±0.02	0.38±0.03
Vitamin C	180.09±0.03	797.95±0.11

Values are mean ± standard deviation of triplicate determinations

The *Terminalia catappa* L. fruit has low content of vitamin A in the seed (0.13±0.02mg/100g) and pulp (0.32±0.03mg/100g). Vitamin A plays key role in visual processes. It promotes growth and differentiation of cellular epithelium, prevents keratinization of skin and eye and promotes resistance to bacterial infection [28].

Vitamin C was found to be abundant in the pulp (797.75±0.11mg/100g) of the fruit (accounting for the sour taste of the pulp when eaten) compared with that present in the seed (180.09±0.03mg/100g). Vitamin C functions in formation of collagen, promotes use of calcium in bone and teeth, promotes elasticity and strength of capillaries and also converts follacin to its active form. Vitamin C stimulates the phagocytic activities of the leucocytes [29].

IV. CONCLUSION

The analyses carried out on the ripe fruits of *Terminalia catappa* L. was to estimate the proximate composition, mineral elements and composition, vitamin composition, antinutrient constituents and caloric values. Proximate analyses show that the fruits have high moisture content relatively higher in the pulp than the seed. The seed of the fruit is a good source of lipid, protein and some minerals like P, Mg, K, Na, Zn and Ca. It also has a higher caloric value.

The pulp is rich in vitamin C and carbohydrate. The availability of vitamins makes the toxicants in the fruit less harmful to humans. In view of all these potentials, it is

important to promote the processing, marketing and consumption of this tropical fruit by all.

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