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NUTRITIONAL COMPOSITION, PHYSICOCHEMICAL AND FUNCTIONAL PROPERTIES OF PEELED AND UNPEELED *DENNETTIA TRIPETALA* (PEPPER FRUIT)

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ABSTRACT

Dennettia tripetala fruits collected from the local market of '*orie ugba'* in Umuahia North LGA of Abia State Nigeria were studied for their nutritional composition, physicochemical and functional properties. Moisture, total ash, crude protein, crude lipid, crude fibre and total available carbohydrate for the peel, whole fruit and dehull seed were determined. The percentage mean values for moisture, total ash, crude protein, crude lipid, crude fibre and total carbohydrates of the peel, whole fruit and dehull seeds were 11.33, 10.83, 12.17 and 4.33, 9.17, 6.00 and 1.51, 1.09, 1.30 and 3.00, 2.17, 1.50 and 38.00, 21.00, 15.67 and 41.83, 55.75, 64.04 while the energy value were 200.50, 246.83 and 271.83 kcal/100 g respectively. The results of physicochemical and functional properties of *Dennettia tripetala* seed oil and flour samples indicated that D. *tripetala* can be used as a raw material for various food products manufacturing and provide consistency in food processing, analogous to other food crops. Therefore, the research findings can be used by food companies in recipe development of D. *tripetala*-based processed foods, including fortified food products to combat the protein-energy malnutrition problem in Nigeria

Key words: *Dennettia tripetala*, Functional, Nutritional, Physicochemical, Proximate.

Running Title: Nutritional, physicochemical and functional properties of ***Dennettia tripetala***

INTRODUCTION

The increasing population of many tropical countries has led to the awareness of the importance of some plants as they are valuable sources of nutrients to man especially in rural areas where they contribute substantially to protein, mineral, vitamins, fiber and other nutrients which are usually in short supply in their daily diets (Enemchukhu *et al*., 2015; Odedeji *et al.*, 2014). Wild plants are used as renewable sources of oil, fuel, food and pharmaceuticals (Adekunle and Ogunrinde, 2004). They are vital link to life, many of such have been identified and lack of data on their chemical composition has limited the prospect of their utilization (Baumer, 1995). Many reports on lesser known seeds and fruits indicate that they could be good sources of nutrients for both man and livestock (Bello *et al*., 2008). Hence, the search for wild edible food plants for human consumption to maintain balance between population growth and agricultural productivity (Vishwakarma and Dubey, 2011).

Dennettia tripetala (pepper fruit) is an indigenous fruit tree of the family *Annonaceae*. It is found mostly in tropical rainforest region and sometimes in the Savannah area notably in western Cameroons, Ivory Coast and communities in some southern states of Nigeria (Ihemeje *et al.*, 2013). Its common name is pepper fruit because of its pungent taste; locally called *'mmịmị'* by the Igbos, '*nkarika*' by the Ibibios and Efik, *'imako'* by the Urhobo and '*ata igbere'* by the Yorubas (Omoregie and Augustine, 2015).

The fruits appear red when ripe and green when unripe, possessing strong pepperish and pungent spicy taste with characteristic refreshing fragrance which has been attributed to the presence of essential oil (oleoresins) (Ndukwu and Nwadibia, 2006). Pepper fruits are either eaten green or red. The flavour of the whole fruit is complex, hard to describe. It is not quite citrus, somewhat blossomy as peaches, and fruity in a savoury way like tomatoes (**Borokini and Ogunyemi,**

2015). The fruit act as a mild stimulant (Ihemeje *et al.*, 2013) and as seasonings and condiments (Nwaogu *et al*., 2007). Previous studies have indicated the presence of phytochemicals like cyanogenic glycosides, saponins and flavonoid (Oyemitan *et al*., 2006) which may indicate its medicinal potential (Donatus and Frank, 2004; Falade *et al*., 2003). The young leaves have spicy taste and are sometimes used to prepare 'pepper soup' delicacies and as condiments in some special local dishes (Ejechi and Akpomedaye 2005). The leaves and the roots in addition to the fruits are utilized for `medicinal purposes (Iwu (1989). It is also used by local herbalists to treat cough, vomiting and stomach upset as well as for masking mouth odour (Oyemitan *et al*., 2006; Oyemitan, 2006). A phenanthrenic alkaloid has also been isolated and characterized from the fruit of the plant (Okwu *et al*., 2005). LG3. The chemical compositions of the leaves have been reported and important nutritive and non-nutritive components such as proximate, vitamin minerals and phytochemicals were found in the leave of the plant (Okoronkwo *et al*., 2011).

Little is known about the nutritional value, physicochemical and functional properties of *Dennettia tripetala* locally grown in South Eastern Nigeria. This information gap does not allow intensive and extensive utilization of *Dennettia tripetala* as a valuable source of nutrient in the region in particu;ar and the country at large. It is upon this background that this study sought to investigate and compare the chemical composition, physicochemical and functional characteristics of ripe and unripe *Dennettia tripetala* grown in South Eastern Nigeria.

MATERIALS AND METHODS

Sample collection and treatment

The fruits of *Dennettia tripetala* fruits used for this study were purchased from '*orie ugba'* a local market in Umuahia North LGA of Abia State Nigeria in June, 2016. The samples were then transported to the laboratory of the department of Pure and Applied Chemistry Usmanu Danfodiyo University where they were sorted, washed and identified by a taxonomist at the herbarium of Botany Unit, Department of Biological Science. The samples were air-dried for seven days, after which they were reduced to fine powder with the aid of a mortar and pestle before being stored in air-tight bottles prior to analytical work.

Proximate analysis

The peels, whole fruits and dehulled seeds were analyzed for its proximate composition. Total nitrogen content was determined by using a Kjeldahl apparatus (AOAC, 1975). The protein content was calculated by ($N \times 6.25$). Moisture, crude fat (ether extract), crude fibre and ash content were determined according to the AOAC methods (AOAC, 1980). Total carbohydrate was estimated as the remainder after accounting for ash, crude fibre, protein and fats (Muller and Tobin, 1980). The gross food energy was estimated according to the method of Osborne and Voogt, 1978 using the equation: food energy in gram calories = (crude protein in % × 4) + (lipid content in % × 9) + (carbohydrates in % × 4).

Oil extraction The crude oil was extracted from the seeds by the use of a soxhlet extractor (Mettle, Switzerland) with *n*-hexane at 40 ^{o}C for 5 hours (Asibey-Berko and Tayie, 1999; Halilu *et al*., 2017). The colour and odour of the extracted oil was examined.

Physicochemical characterization of the extracted oil

The method described by Ogunwole 2015 was used to determine the acid value and iodine value. The methods described by Knothe 2009, Mustapha 2016 and Lea 1946 with slight modifications was used to determine the free fatty acid content, saponification value and peroxide value respectively.

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Functional properties

Water absorption capacity

The water absorption capacity was determined according to the method described by Gould *et al.,* (1989). 1.00 g of the dried fruit sample was weighed into a centrifugal tube, 10 cm^3 of distilled water was added and mixed thoroughly by shaking for 30 seconds. The sample was allowed to hydrate for 2 hours at room temperature before being centrifuged at 3000 rpm for 10 minutes. The supernatant was discarded and the hydrated sample was weighed. The determination was performed in triplicate and the water absorption caapacity determined according to the expression represented in equation (1)

$$Water\ holding\ capacity\ \left(\frac{g}{g}\right) = \frac{Weight\ of\ hydrated(g)\ –Weight\ of\ dry\ sample(g)}{Weight\ of\ dry\ sample\ (g)} \quad - \qquad (1)$$

Oil absorption capacity

The oil absorption capacity was determined according to the method described by Caprez *et al.,* (1986). 1.00 g of the dried fruit sample was weighed into a centrifugal tube, 10 cm^3 of olive oil was added and mixed thoroughly by shaking for 30 seconds. The sample was allowed to stand for 1 hour at room temperature before being centrifuged at 3000 rpm for 10 minutes. The supernatant was discarded and the pellet was weighed. The determination was performed in triplicate and the oil absorption capacity determined according to the expression represented in equation (2)

$$Oil\ holding\ capacity\ \left(\frac{g}{g}\right) = \frac{Weight\ of\ pallet(g) - Weight\ of\ dry\ sample(g)}{Weight\ of\ dry\ sample} \quad - \quad - \qquad (2)$$

Bulk Density

The bulk density of the dried fruit sample was determined according to the method described by Akpapunam and Markakis (1981) with slight modifications. An empty calibrated measuring cylinder was weighed and filled with a sample to the 5 ml mark by constant tapping until there was no further change in volume. The bulk density was calculated as the ratio of sample weight to the volume of expanded sample in the cylinder. The determination was performed in triplicate and the bulk density (w/v).determined according to the expression represented in equation (3)

$$Bulk\ density\ \left(\frac{g}{mL}\right) = \frac{Weight\ of\ dispersed\ sample}{Volume\ determined} \qquad (3)$$

Water Absorption Index (WAI)

WAI was determined according to the method described by Ruales *et al.* (1993) with slight modifications. 2.5 g dried fruit sample was suspended in 10 cm^3 of distilled water at room temperature for 30 min, gently stirred during this period, and then centrifuged at 3000 rpm for 10 minutes. The supernatants were decanted into an evaporating dish of known weight. The WAI was the weight of gel obtained after removal of the supernatant per unit weight of original dry solids. The determination was performed in triplicate and the WSI determined according to the expression represented in equation (4)

$$WAI\ \left(\frac{g}{g}\right) = \frac{Weight\ of\ sediment}{Weight\ of\ dry\ solids} \qquad (4)$$

Water binding capacity

The water binding capacity (WBC) was determined according to the method described by Medcalf and Gillies (1965). 15 cm^3 of distilled water was added to 1.25 g of the dried fruit sample in a centrifuge tube of known weight and centrifuged at 3000 rpm for 10 minutes. The weight of the centrifuge tube and content was determined after decanting the water and allowed to drain for another 10 minutes. The bound water was determined by the change in weight. The determination was performed in triplicate and the WBC determined according to the expression represented in equation (5)

$$WBC = \frac{Bound\ water\ (g)}{Weight\ of\ sample\ (g)}\ X\ 100 \quad - \quad - \quad - \quad - \quad - \quad - \quad - \qquad (5)$$

RESULTS AND DISCUSSION

Proximate composition

The result of the nutritional analysis of *D. tripetala* fruit shown in table 1 reveals that it is a good source of dietary nutrients.

Table 1: Proximate composition of *Dennettia tripetala* peel, whole fruit and dehulled seed.

Parameters	Peels	Whole fruit	Dehull seed
Moisture (%)	11.33±0.24	10.83±0.62	12.17±0.24
Ash (%)	4.33±0.67	9.17±0.62	6.00±0.41
Crude Protein (%)	1.51±0.05	1.09±0.02	1.30±0.02
Crude Lipid (%)	3.00±0.41	2.17±0.24	1.50±0.00
Crude Fibre (%)	38.00±1.47	21.00±0.71	15.67±1.03
Available Carbohydrate (%)	41.83±1.28	55.75±0.63	64.04±2.05
Energy Value (kcal/100g)	200.5±8.83	246.83±3.57	271.83±8.25

The data are mean ± standard deviation (SD) of three replicates.

The results shows that the moisture content is in the order whole fruit < peels < dehull seeds. This suggests that the whole fruits will be less prone to microbial spoilage than the peels and dehulled seeds. Moisture content is an index of stability and quality although some other factors apart from season affect the moisture content such as the location of the plant and the stage of maturity of the fruit before harvest. The crude protein of the whole fruit (1.09±0.02) is lower than that of the dehull seeds (1.30±0.02) and peels (1.51±0.05) respectively. The result is lower than the 15.31% reported by Donatus and Frank, 2004 and 4.67% obtained by Ihemeje *et al.* 2013 for the whole ripe fruits of *Dennettia tripetala* respectively. The ash content of whole fruit of *Dennettia tripetala* in this study (9.17±0.62) is not within the 6.30 - 8.53g/100g range given by Oluyemi *et al.,* 2006 for commonly consumed fruits. This is an indication that *Dennettia tripetala* fruits can be good substitutes for more expensive fruits in terms of mineral components. The values obtained for crude protein in this study indicate that the fruits are good sources of protein and might supplement the supply of essential amino acids to the body. The crude lipid content of the whole fruit (2.17±0.24) was found to be higher than the dehull seeds (1.50±0.00) but lower than that of the fruit peels (3.00±0.41). This shows that the whole fruit may not be a good source of edible oil for commercial purpose since fat promotes fat soluble vitamins absorption and therefore very important in diets. Fibre has a biological effect not only on the absorption and reabsorption of cholesterol and bile acid but also on gastrointestinal function by promoting the reduction of tracolonic pressure, which is beneficial in diverticular disease (Akobundu, 1999). Fibre helps to prevent the reabsorption of bile acids and, consequently, of dietary fat cholesterol. This, in turn, lowers the cholesterol and prevents the formation of plaques whose components are cholesterol, some fats and protein (Scala, 1974). The crude fibre values obtained for the fruit peels, whole fruit and dehull seeds are 38.00±1.47, 21.00±0.71 and 15.67±1.03 respectively. These values are higher than 17.05% and 9.84% reported by Ihemeje *et al*. 2013 and Donatus and Frank 2004 respectively. Nutritionist recommended a daily intake of 15 – 18 g of dietary fibre or 6g of crude fibre (Charles-Merie, 1992). The fruits therefore are regarded as healthy food and their consumption beneficial promoting bowel regularity, softens stools and enhances frequent waste elimination, including bile acids, sterols and fat (Umoh, 1998). The available carbohydrate comprises sugars such as glucose, sucrose and fructose, hemicellulose and pectin, which act as dietary fibre, add bulk to the diet and may sometimes, act as a mild natural laxative for human beings (Enwere, 1998). The values obtained for carbohydrate which were 41.83±1.28 and 64.04±2.05 for the fruit peels and dehull respectively shows that it is the seeds that has higher carbohydrate content than the peels of the fruit. Since high carbohydrate content in food is desirable for energy (Baker, 1995), it is recommended that the seeds should be consumed if energy is desired from the fruit consumption as this is confirmed by the energy value of 271.83±8.25 as against 246.83±3.57 and 200.5±8.83 obtained for the whole fruit and fruit peel respectively.

Physicochemical Characteristics of *Dennettia tripetala* seed oil

The volatile oil in *D. tripetala* is responsible for the pleasant and refreshing aroma observed (Table 2). This is responsible for its inclusion in food as a spice and flavouring agent for meal preparations, soups, sauces and canned foods (Enwere, 1998).

Table 2: Physicochemical characteristics of *Dennettia tripetala* seed oil

Parameter	*Dennettia tripetala* seed oil	ASTM (2002)
Yield (%)	3.00	-
Colour	Brown	-
Odour	Pleasant and Refreshing	-
Acid Value (mg KOH/g)	57.74±0.47	0.50
Peroxide Value	30.00±2.45	-
Iodine Value (g I_2/100g)	35.66±0.92	130
Saponification Value (mgKOH/g)	191.36±10.17	-
Free Fatty Acid	50.01±0.87	0.50

The data are mean ± standard deviation (SD) of three replicates. Key: (-) = Not applicable

The acid value of *Dennettia tripetala* seed oil was found to be 57.74±0.47 mg KOH/g. Acid value is the index of the free fatty acid content that will be due to enzymatic activity. The acid value is a familiar parameter in the specification of fat and oils. On the basis of acidity, the oil cannot be used for human utilization, since the acid value is higher than the maximum acceptable value of 4 mg KOH/g recommended by Codex Alimenterus Commission (Gotoh and Wada, 2006; Halilu *et al.,* 2017). However, this does not mean consuming *D. tripetala* is harmful because its oil yield is just 3%. The reported acid value thou greater than the maximum value set by ASTM is an indication that the seed oil once used to produce biodiesel would have corrosion problem when used or stored (Ogunwole, 2015). Peroxide value is used as a measure of the extent to which rancidity reactions will occur during storage, hence it could be used as an indication of the quality and stability of fats and oils (Ekwu and Nwagu, 2004). The peroxide value of *D. tripetala* seed oil was found to be 30.00±2.45 indicating that the seed is of good quality and stable to rancidity. The iodine value is an index of unsaturation. Iodine values are often used to determine the amount of unsaturation in fatty acids. Oils with iodine values within 80-125 g/100g are considered non-drying oil (Badifu and Ogunsua, 1991; Kochhlar, 1998). The value obtained indicates that the oil is drying liquid oil. The iodine value (35.66±0.92 g/100g) of the oil sample indicates that the oil may be of high interest in the coating industry (Aigbodion *et al.*, 2004), and could also be used in the preparation of soap, cosmetics, lubricants, and candle wax (Gotoh and Wada, 2006; Halilu *et al.*, 2017). With reference to ASTM standard specification, the reported iodine values of the seed oil indicate that it will produce quality biodiesel. The saponification value of the oil obtained from the dehulled seeds was found to be 191.36±10.17 mgKOH/g. Saponification value is a measure of the equivalent weight of fatty acids present in the oil sample (Entaman, 1982). Oil whose saponification value is greater than or equal to 200 mgKOH/g is regarded as possessing high molecular weight fatty acid which can be used for soap making (Gunstone *et al.*, 1986; Warra *et al.*, 2011). The saponification value provides some information on the structure of fatty acids (Gunstone *et al.*, 1986). The saponification value of *D. tripetala* shown in this study confirms that it has a very low potential for both large and local scale manufacturing, especially in soap production. It is therefore only recommended as food ingredient because of its medicinal, cleansing and flavoring potentials.

Functional Properties Analysis

The results for the functional properties of *D. tripetala* floured seed are presented in Table 3. These properties are crucial in the eventual consideration of the flour (powdered) seed sample in the formulation of ground meals

Table 3: Functional Properties of *Dennettia tripetala* Grounded Seed

Property	Value
Water absorption capacity (g/g)	3.21±0.01
Oil absorption capacity (g/g)	2.74±0.00
Bulk density (g/mL)	0.43±0.00
Water absorption index	3.41±0.00
Water binding capacity	1181.57±0.34

The data are mean ± standard deviation (SD) of three replicates.

A number of factors such as hydrophilic-hydrophobic balance of amino acids molecular size and shape influence the water absorption of flours. There are economic benefits in adding water to a product which is priced according to its weight, and a positive impact on the shelf life, hence food manufacturers prefer to incorporate food ingredients with high water absorption capacities in their formulations. Oil absorption capacity is a measure of the binding of fat to the non-polar side chains of proteins. High oil absorption of protein is required in meal formulation, meat replacers and extenders, doughnuts, baked goods and soups (Tizazu and Emire, 2010); Aziah and Komathi, 2009). The water and oil absorption capacity was found to be 3.21±0.01 and 2.74±0.00 respectively which was higher than 2.65 ± 0.07; 2.05 ± 0.07 and 1.82 ± 0.00; 1.64 ± 0.26 reported by Tizazu and Emire, 2010 for *Lupinus albus* seeds procured from Debretabor and Dembecha local markets in Ethiopia. Bulk density is a very important parameter in the production of extruded products. Density is a measure of the expansion occurred during extrusion process (Filli *et al*., 2013). The bulk density was found to be 0.43±0.00 which is lower than 0.61 ± 0.007 and 0.75 ± 0.011 reported by Tizazu and Emire, 2010 for *Lupinus albus* seeds procured from Debretabor and Dembecha local markets in Ethiopia. Bulk density is affected by particle size and density of the flour involved and it is very important in determining the packaging requirements, material handling and the application in wet processing in food industry (Adebowale *et al*., 2008). The water absorption index (WAI) and water binding capacity (WBC) was found to be 3.41±0.00 and 1181.57±0.34 respectively. Both WAI and WBC is an *in vitro* indicator of good starch digestibility as it implies the extent of gelatinization and dextrinization (Guha *et al*., 1997). While the WAI measures the amount of water absorbed by starch and can be used as an index of gelatinization (Anderson *et al*., 1969), WBC is an indicator of the degradation of its molecular components (Kirby *et al*., 1988). WBC measures the amount of soluble components converted and released from the starch after extrusion which corresponds to the amount of soluble polysaccharide released from the starch granule (Ding *et al*., 2005). WAI depends on the availability of hydrophilic groups that bind water molecules.

Conclusion

The results of this research exemplified that *Dennettia tripetala* fruit grown in South Eastern Nigeria is a very nutritious crops rich in the studied nutritional parameters. The results of the physicochemical and functional properties indicated that *Dennettia tripetala* can be used for various food products manufacturing analogous to other food crops. Therefore, the research findings can be used by food companies in recipe development of *D. tripetala* -based processed foods, including fortified food products to combat the protein-energy malnutrition problem in Nigeria.

Conflict of Interest

Authors state that there is no conflict of interest.

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