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Composition of Coconut (*Cocos nucifera* L. Cv. Fiji Dwarf) Edible Endosperm and Physicochemical Properties of its Oil

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Abstracts
Coconut (*Cocos nucifera* L.) is one of the most important oil producing crops in the world. It has enormous industrial and health benefits. To affirm the foregoing, the proximate and physicochemical constituents of the oil extracted from the edible endosperm were determined. The results showed that percentage moisture, protein, ash, crude fat, crude fibre and carbohydrate had respective values of 42.39 %, 6.21 %, 1.04 %, 17.18 %, 8.95, and 23.69 %. The edible mesocarp has high amount of mineral elements such nitrogen, potassium, calcium and phosphorus. Whereas, elements such as sodium, manganese, magnesium, copper and chlorine occurred in low quantity. The physicochemical properties of the oil showed a refractive index of 1.46, specific gravity of 0.92 g/cm^3, acid value of 2.15 %, free fatty acid of 1.08 %, saponification of 125.980 mgKOH/g and iodine value of 2.89 indicating that the oil is good for consumption. Given, the results of proximate and mineral compositions, the edible endosperm could therefore be considered as good source of energy and alternative source of dietary supplement for human nutrition.

Keywords: Coconut, proximate analysis, mineral composition, dietary supplements

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Introduction

Coconuts (*Cocos nucifera* L.), is a large palm tree growing up to 30 meters tall and belong to the family Arecaceae, and are mainly cultivated in the tropical area (Ojobor *et al*., 2018). It exhibits good digestibility and is rich in oil in medium chain fatty acids (Cheman and Marina, 2006). The plant was assumed to have originated from South East Asia (Imo *et al*., 2018). It is called "Aki bekee" in Igbo, "Agbon" in Yoruba and "Kwakwa" in Hausa. It has been observed that all part of the plant is useful and thus it is widely called tree of life (Boureix *et al*., 2006). Due to its significant contribution to human life, it is utilized for the benefit of human race and its fruit provide important constituent of food (Magat, 1999), thus its different parts have been put to domestic, commercial and industrial uses (Chan and Elevitch, 2006). It has been reported to be the most importantly and extensively grown palms in the world (Onifade and Jeff-Agboola, 2003). In 2018, Indonesian was

found to be the largest producer of coconut 18.56 million metric tonnes followed by Philippines (14.72 million metric tonnes) and India (11.71 million metric tonnes), while Nigeria is in a distance 19th position with 285,200 metric tonnes (FAO, 2018).

Coconut can be consumed raw and can also be processed into desire texture such as coconut oil cake, cookies, pies, desserts, coconut copra, coconut oil, coconut skin milk and coconut protein (Onifade and Jeff-Agboola, 2003; Imo *et al*., 2018). It contains a large quantity of water which may be harvested for drinking when the coconut is immature (Ojobor *et al*., 2018). Due to its low toxicity, it has been investigated for many potential nutritional, medicinal and pharmaceutical uses. Coconut water and coconut endocarp has been reported to exhibit antioxidant, antifungal, antitumor and antimicrobial activities (Lima *et al*., 2015). The coconut husk has been used for the treatment of diarrhea and arthritis, while the water extract of the coconut husk fiber exhibit antimicrobial activity (Esquenazi *et al*., 2002). It is used in the industry for separation of glycerin and fatty acids, production of soap, detergent, biodiesel and coco-methyl-ester (CME) for mixture with regular mixture (Foale, 2003). The mineral and proximate composition of coconut shell, has showed its potential use as an effective material precursor for the treatment of water and wastewater (Ewansiha, 2012).

Three types of fibers are obtained from the coconut husks which include mat fiber or yam fiber used in making mats, bristle fiber used for brush making and mattress fiber, used in miffing mattress and in upholstery. Coconut leaflets are used in braiding mats, baskets and hats. The timber obtained has traditionally been used in tropical countries for the structural framework of houses. Coconut timber taken from the lower and middle parts of the trunk can be used for load-bearing structures in building, such as frames, floors and trusses. Coconut trunks can be used for poles, as they have great strength and flexibility. The wood can also be used for furniture and parquet flooring (Foale and Ashburner, 2004). In this work, the proximate and mineral composition of coconut mesocarp and physicochemical properties of its oil are investigated.

Materials and Methods

Sample collection and preparation

The coconut fruits were purchased in Oja Oba (Ilorin Central) market, Kwara State, Nigeria. The fruits were identified and authenticated at the Department of Plant biology, University of Ilorin. The epicarp of the fruits were broken and the fleshy endosperm was removed, cut into small pieces, sun-dried and crushed with an electric blender. The blended sample was used for proximate and mineral analysis.

For the physicochemical analysis of the oil, the coconut endosperm was soaked in hot tap water (1;1 w/v), following a previously reported method (Odenigbo and Otisi, 2011), with slight modification. It was allowed to cooled and then squeezed and filtered and the coconut milk was pooled into a clean jay and was left for 1hr. The resulting lower phase containing the protein was drained off, while the upper phase was then fermented overnight to get the oil extract. All chemicals used are of analytical grades.

Proximate analysis

The proximate analysis was carried out according to standard procedures (AOAC, 2005). The total ash was determined by heating 2 g of the sample in a muffle furnace at 600°C until the appearance of grey white ash. Crude protein was determined using Kjedjahl method in a digestion flask. Moisture content was determined by oven drying of 2 g of the sample to a constant weight. Fat content was estimated using a continuous extraction method. The carbohydrate was estimated obtained after substracting the organic protein, ash content, fat content, crude fiber and moisture content from 100 %.

Mineral Analysis

The iron, Zinc, calcium, chromium, magnesium and manganese were determined using atomic absorption spectrometer (AAS), while sodium potassium and calcium were determined using Flame photometer. The Sample was prepared by dissolving one gram

of the coconut mesocarp into a digestion tube, following by addition of 20 cm^3 of 3 M Nitric acid. The solution was then filtered into a volumetric flask and then made up to the mark. The resulting solution was subjected to AAS analysis.

Physicochemical Analysis

The extracted oil was investigated for its iodine, saponification, acid values, percentage free fatty acid specific gravity and refractive index

Iodine value

Wij's method was used to determine the iodine value (Pearson, 1976), which is expressed in mg I_2/100 g of oil. Briefly, 0.3 g of the oil was weighed into a conical flask followed by addition of 20 cm^3 of CCl_4. Then, 25 cm^3 of Wij's reagent was added using a safety pipette in the fume chamber and a stopper was inserted and the flask was swirled vigorously. The flask was then placed in the dark for 30 min, after which 20 cm^3 of 10 % aqueous potassium iodide, 100 cm^3 of distilled water were added. The liberated iodine was then titrated against 0.1 M sodium thiosulphate solution to a colourless endpoint. Two drops of starch indicator were then added and the titration continued by drop wise addition of sodium thiosulphate until blue colour disappear after shaken vigorously. A blank determination was also carried out. The iodine value is then calculated using the equation:

$$Iodine\ value\ (IV) = 12.96\frac{V_1 - V_2}{M}$$

Where, V_1 = volume of sodium thiosulphate used for blank; V_2 = volume of sodium thiosulphate used for sample and M = Mass of the sample.

Saponification value

To determine the saponification value, 2 of the oil was transferred into a flask contacting 30 cm^3 of ethanolic KOH and the flask was then attached to a condenser for 40 min to ensure complete dissolution of the sample. The sample was cooled and 1 cm^3 of phenolphthalein was added and then titrated against 0.1M HCL to a pink end point. A blank solution was also analyzed. And the saponification value is calculated using the equation (Senchi & Elinge, 2020):

$$Saponification = \frac{(S-B)\ x\ M\ x\ 56.1}{w}$$

Where S is the titre value of sample, B is the titer value of blank, M is Molarity of HCl; 56.1 is the molar mass of KOH and w is the mass of sample.

Acid values

The acid value was estimated by heating 2 g of the oil sample with 100 cm^3 of neutral ethyl alcohol in 250 cm^3 beaker until the mixture boiled. The mixture was then titrate against 0.1 M KOH solution with vigorous shaking using phenolphthalein indicator until a permanent pink end point. Acid value was then calculated using the equation

$$Acid\ value = \frac{M\ x\ C\ x\ V}{w}$$

Where M is the molar mass of KOH (56.1), C is the concentration of KOH, V is the volume of KOH used and w is the weight of the oil (Senchi and Elinge, 2020).

Percentage free fatty acid

Two grams of well mixed sample was accurately weighted into a conical flask in to which 10ml of neutralized 95% ethanol and phenolphthalein indicator were added. This was titrated with 0.1 M NaOH, shaking constantly until a pink color persisted for 30 s. the percentage free fatty acid was calculated from Equation.

$$\%FFA = \frac{M\ x\ V\ x\ 2.82}{w}$$

Where V is the Volume of NaOH used, M is the molar concentration of NaOH, 2.82 is the conversion factor for oleic acid and w is the weight of sample

Specific gravity

The specific gravity was determined using a specific gravity bottle. The specific gravity is then given as the ratio of the weight of the bottle in air of a given volume of oil at the defined temperature to that of the same volume of water at the same temperature (AOAC, 2005).

A cleaned and dried pycnometer was weighted, and filled with water maintained at 20 °C and re-weighted. The bottle was emptied, dried and filled with oil and weighted. The specific gravity is calculated with formula shown below:

$$Specific\ gravity = \frac{W_3 - W_2}{W_1}$$

Where W_3 is the weight of container and oil, W_2 is the weight of empty container, while W_1 is the weight of equal volume of water.

Refractive index.

The refractive indices, ɳ40 D, (RI) of the oil sample was measured using the Abbe refractometer connected to a thermostatically controlled water bath that maintained the temperature of the refractometer at 40 ± 0.1 °C.

Data Analysis

Data obtained were subjected to statistical analysis using one way analysis of variance (ANOVA).

Results

Proximate Analysis

The results of the proximate analysis of the endosperm of *Cocos nucifera* is presented in Table 1. The results showed that *Cocos nucifera* endosperm contained moisture content of 42.39±0.67 %, ash content of 1.04±0.05 %, crude fiber of 8.95±0.26 %, crude fat of 17.80±0.29 %, crude protein of 6.21±0.04 and carbohydrate of 23.64±0.78 %.

Mineral Analysis

The results of the mineral content of the endosperm of *Cocos nucifera* are presented in Table 2. The mineral analysis showed some intriguing results of which nitrogen was found to be have highest amount (58.86±0.24 mg/100g), while manganese found to be lowest (2.12±0.10 mg/100g). The trace mineral constituent of copper and chlorine were 0.61±0.10 mg/100g and 0.47v0.24 mg/100g, respectively.

Physicochemical Analysis

The results of the physiochemical properties of coconut endosperm as presented in Table 3 showed that nine (9) minerals were observed to be present in *Cocos nucifera*. The iodine value present in the sample was found to be within 2.89±0.01 mg/100g, which indicates the starch component in the sample. The saponification value was found to be 126.07±0.13 mgKOH/g, which is high and good in soap making. The percentage acid value present was 2.15±0.02 and the free fatty acid present was 1.08±0.01%, which indicate the presence of lipid. Specific gravity of the sample was 0.92±0.01 g/cm^3, which allows access to molecular information in a non-invasive way. The refractive index of the sample was 1.46±0.01n which indicates that the fatty acid in the oil contains lower number of carbon atoms.

Table 1: Proximate composition of *Cocos nucifera* endosperm

Proximate composition	Value (%)
Moisture content	42.39±0.67
Ash content	1.04±0.05
Crude fiber	8.95+0.26
Crude fat	17.80±0.29
Protein	6.21±0.04
Carbohydrate	23.64±0.78

N.B.: values are mean ± standard deviation (SD) of samples analyzed in triplicate

Table 2: Mineral composition of *Cocos nucifera* endosperm

Mineral composition	Value (mg/100g)
Phosphorus	5.64±0.02
Calcium	8.02±0.05
Magnesium	1.22±0.22
Sodium	2.76±0.12
Potassium	20.30±0.01
Nitrogen	58.86±0.24
Manganese	2.12±0.10
Copper	0.61±0.10
Chlorine	0.47±0.24

N.B.: values are mean ± standard deviation (SD) of samples analyzed in triplicate

Table 3: Physicochemical properties of *Cocos nucifera* endosperm

Physicochemical Properties	Value
Iodine value (mg/100g)	2.89±0.01
Saponification vale (mgKOH/g)	126.07±0.13
Acid value (%)	2.15±0.02
Free fatty acid (%)	1.08±0.01
Specific gravity (g/cm^3)	0.92±0.01
Refractive index (n)	1.46±0.01

N.B.: values are mean ± standard deviation (SD) of samples analyzed in triplicate

Discussion

The overall nutritional composition is given by the proximate analysis (Ojobor *et* al., 2015). The proximate analyses result of the coconut sample studied revealed that the percentage ash content was approximately 1.00 which shows that coconut oil contains relatively fair amount of minerals. Khor *et al*., (2014) reported ash values than 1% in some varieties of Malaysian coconuts, meanwhile Adeola and Ndudi (2012) documented coconut ash values than 2% for some Nigerian varieties. The variations in ash content of the oil-bearing plant might be influenced by environmental and genetic interactions. The ash value obtained in the present study was much more lover than the 6.20g/100g ash content reported for *Irvingea garbonesis* by Ogunsina *et al*., (2012) which shows that ash content of oil seeds varied from species to species.

Interestingly, the percentage protein in coconut samples studies was 6.23 which is similar to the result published by Ogunsina *et al*., (2012) but in contrast and much lower (less than 1%) than the values reported for Malaysian varieties (Khor *et al*., 2014). However, comparatively the percentage crude protein in coconut oil is less than other oil-bearing seeds such as shear nut, sesame and cuminis (Ouattara *et al*., 2015) and cotton (Adeola and Ndudi, 2012). The fiber in the oil plays a very important nutritional role in human nutrition and it has been associated with beneficial role in diverticular disease by diluting out potential carcinogens and spreading their transit through the colon, thus reducing the risk of colon cancer (Ouattara *et al*., 2015). The relatively high fiber content of the studied coconut oil is concurrent to the value obtained by Ghosh et al. (2014) and could contribute to it choice as domestic oil as well as industrial application. Less amount of crude fibre was found in cottonseed oil (Adeola and Ndudi, 2012).

The moisture content is an important quality characteristic for oils and fats (Mansor *et al*., 2012). It is desirable to keep the moisture content low as it will increase the shelf life by preventing oxidation and rancidity processes.

The high moisture content will assist hydrolysis process (Osawa *et al*., 2007). Moreover, the high moisture level, with values above 42% may cause the samples to be more susceptible to microbial spoilage; therefore, combating this issue should be taken into consideration as opined by Khor *et al*. (2014). Carbohydrate content of 23.085 signifies the moderate calorie lock in the coconut oil, due to this moderate energy source, the oil would find a vintage and contemporary utilization in domestic and industrial utilization for animal feed and other uses. The low crude Fat was lower than those of sesame, groundnut, shear and cucumis (Ouattara *et al*., 2015).

The fiber, protein and carbohydrate content of the sample showed that it is rich in nutrients and could be used as an alternative source of dietary fiber and energy (Ojobor, 2018). The presence of carbon containing compounds in the sample was indicated by the ash content, and thus can be used as an adsorbent in water purification. The results of this study showed that *Cocos nucifera* is a better source of carbohydrate than protein, which agreed with the study of Imo *et al*., (2018). The presence of protein, indicated that the sample contains certain important essential amino acids, which plays a vital role in growth regulation and catalytic activities of some enzymes (Imo *et al*., 2018).

The identified minerals are of great importance to human health. *Cocos nucifera* could help in the regulation of homeostatic balance, which helps in the proper functioning of cells, nerves, bones and muscles as a result of the presence of minerals such as sodium, calcium and phosphorus (Soetan *et al*., 2010). The copper, which helps in cellular defense and chlorine content were low, and this showed that they are required in small amount in the body (Imo *et al*., 2018). Calcium and phosphorus plays an important role in building stronger denser bones and calcium act as a cofactor of some enzymes (Ojobor *et al*., 2015). Potassium helps to regulate heartbeat and proper functioning of the muscle. Sodium helps in ionic exchange and balance of negative and positive ions in the kidney. Manganese is required for the proper functioning of the pituitary gland, by promoting the hepatorenal function (Ojobor *et al*., 2018). The consumption of coconut is encouraged because of the presence of minerals that are required for vital metabolic activities in the body.

Iodine value is the measurement of the degree of unsaturation in oil. The result of the physiochemical properties revealed iodine value of 2.893, depicting that coconut oil have unsaturated compound (Pearson, 1976). Low unsaturation provides high oxidative stability to oils, while high saponification value indicates the unsaturated level of the oil and similar to those of groundnut oil, and sesame oil (Outtara *et al*., 2015) which implies coconut oil is suitable for manufacture of soap. The acid value of the studied samples showed that the level of the glycerides in the oil had been decomposed by lipase action. Therefore, coconut oil is still in good condition and edible.

The free fatty acid of the coconut oil is 1.075, free fatty acid content is an indicator of the hydrolytic rancidity of the coconut oil which causes an undesirable flavor and aroma in the oil. Hydrolytic rancidity is mainly due to the action of lipase or moisture (Hoover *et al*., 1973). The hydrolytic rancidity in coconut oil is mostly attributed to the undesirable storage, maintaining the quality of copra and the moisture content of the extracted oil. The oil extracted from under-dried stored copra increase the incidence of free fatty acid in the oil substantially. The specific gravity is 0.908, indicating that the molecular weight is higher in the unsaturated oil. The refractive index is 1.451, this is for the identification of oil and it also shows the purity or the fluctuation of the oil.

Conclusion

The proximate composition, mineral analysis and physicochemical properties of *Cocos nucifera* endosperm evaluated in this study showed that, it is highly nutritious, with appreciable level of nutrients, dietary fiber and energy that are essential for immunological, physiological and pharmacological activities in the body. It also showed that edible endosperm could be

a good source of food supplement. The oil had high level of good characteristics and it compared favourably with most conventional vegetable oils. The use of the oil in baked and cosmetic products should therefore be encouraged.

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