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Proximate Composition, Extraction, Characterization and Comparative Assessment of Coconut (*Cocos nucifera*) and Melon (*Colocynthis citrullus*) Seeds and Seed Oils

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Abstract: Proximate composition, extraction, characterization and comparative assessment of *Cocos nucifera* and *Colocynthis citrullus* seeds and seed oils were evaluated in this work using standard analytical techniques. The results showed the percentage (%) moisture, crude fibre, ash, crude protein, lipids and total carbohydrate contents of the seeds as 7.51 and 4.27, 7.70 and 5.51, 1.02 and 2.94, 10.57 and 11.67, 47.80 and 50.42 and 32.84 and 29.47 while the calorific values were 553.99 and 567.32 Kcal/100 g for *C. nucifera* and *C. citrullus*, respectively. The two seed oils were odourless and at room temperature (30°C) liquids, with a pale yellow to yellowish colouration. Lipid indices of the seed oils indicated the Acid Values (AV) as 2.06-6.36 mg NaOH g^{-1} and 2.99-6.17 mg NaOH g^{-1}, Free Fatty Acids (FFA) as 1.03-3.18 and 1.49-3.09%, Saponification Values (SV) as 252.44-257.59 and 196.82-201.03 mg KOH g^{-1}, Iodine Values (IV) as 9.73-10.99 and 110.93-111.46 mg of I_2 g^{-1} of oil and Peroxide Values (PV) as 0.21-0.21 and 1.53-2.72 mg O_2 kg^{-1} for soxhlet-mechanical extracted *C. nucifera* and *C. citrullus* seed oils, respectively. The studied characteristics of the oil extracts in most cases compared favourably with most conventional vegetable oils sold in the Nigeria markets; however, there were some observed levels of significant differences in the values at $p \leq 0.05$. These results suggest that the seeds examined may be nutritionally potent and also viable sources of seed oils judging by their oil yield. The data also showed that the seed oils were edible inferring from their low AV and their corresponding low FFA contents. Industrially, the results revealed the seed oils to have great potentials in soap manufacturing industries because of their high SV. They were also shown to be non-drying due to their low IV which also suggested that the oils contain few unsaturated bonds and therefore have low susceptibility to oxidative rancidity and deterioration as confirmed by their low PV which also serves as indicators of the presence or high levels of anti-oxidants in the oils.

Key words: Proximate composition, lipid indices, *Cocos nucifera*, *Colocynthis, citrullus,* seed oil

INTRODUCTION

The nutritive and calorific values of seeds make them good sources of edible oils and fats diet (Akubugwo *et al.*, 2008; Odoemelam, 2005). Seed oils have extensive demands both for human consumption and for industrial applications (Kyari, 2008) and also have been rated as the second most valuable commodity in the world trade today (Ige *et al.*, 1984).

Coconut (*Cocos nucifera* Linn.; Family-*Palmae*) is one of the most extensively grown and used nuts in the world and is rated as one of the most important of all palms (Onifade and Jeff-Agboola, 2003; Popenoe, 1969). Out of the 100 products that are directly or indirectly made from coconuts, eight are important in world trade. These are whole coconut, copra, coconut oil, coconut oil cake, coir, desiccated shredded coconut, coconut skim milk and coconut protein (Onifade and Jeff-Agboola, 2003). Coconut can also be used to produce desired texture in cookies, candies, cakes, pies, salads and desserts. Coconut is commercially viable because of its rich nutritive values (Akubugwo *et al.*, 2008; Kyari, 2008; Child, 1964).

Melon (*Colocynthis citrullus*; Family-Cucurbitaceae) is a variety of melon seeds popularly called 'egusi' in West Africa. It is a creeping annual plant

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and an intercropping plant made use in traditional farming practices, thrives well on rich light soil in the hot climate regions of Africa (Akpambang *et al*., 2008). It however, has been noted to tolerate low rainfall (Cobley, 1957). In the South-Eastern region of Nigeria, egusi is best cultivated after the first rains of the year (Ogbonna and Obi, 2000). The first fruits are harvested at about thirteen weeks after planting. The seeds are obtained either in shelled or unshelled forms in West African markets and are used greatly in West African cookery. The melon seeds can be milled and used to prepare a popular 'egusi' soup where it acts as a food thickener. It can also be fermented to produce ''ogiri'' and used as condiments to season or flavor soup (Yusuf *et al*., 2006; Achinewu, 1987). Melon seeds may also be eaten as snacks, either as whole toasted seeds or as fried cake prepared from milled seeds (Okigbo, 1984; Odunfa, 1981).

Numerous researchers (Akubugwo *et al*., 2008; Kyari, 2008; Yusuf *et al*., 2006; Akpan *et al*., 1999) among others have carried out a lot of analytical works on seeds primarily because of extensive and increasing demands for them both for human consumption and for numerous industrial applications. Consequently, there is an increasing need to perpetually search for oils from non-conventional sources to augment the available ones and also to meet specific applications. Attention has not been focused on under-utilized agricultural foods and industrial products. This study therefore, is designed to search for oils from non-conventional sources because of the increasing needs for oils both for human consumption and industrial applications and also to assess the nutritional values of coconut and melon seeds for maximum utilization in the production of various products for food and animal feeds.

MATERIALS AND METHODS

Collection and processing of samples: Healthy coconut and melon seeds were obtained from Sabon Gari market, Kano, Kano State. The seeds were taken to Bayero University, Kano where they were authenticated by a taxonomist. Standard methods for sample processing and preparation and analytical procedures were used.

The coconuts were dehauled mechanically with knife and the inner hard shells removed. It was then carefully broken and the seeds collected and sun-dried to reduce the moisture content. Thereafter, it was milled manually using milling machine (Model Ed-S), wrapped in polythene bags and kept in a desiccator until needed.

The melon seeds were hand peeled to remove the husks. Thereafter, the peeled seeds were sun-dried and milled manually using machine (model Ed-S), wrapped in polythene bags and kept in a desiccators until needed.

Proximate and lipid indices analysis: Proximate analysis was carried out on the processed samples to determine the percentage moisture, crude fibre, ash, protein, lipid and carbohydrate using standard methods of analysis. The moisture contents of the processed samples were determined by the gravimetric method of AOAC as outlined by Pearson (1976). The crude fibre contents were determined by the Weende method outlined by Pearson (1976). The percentage ash contents of the samples were determined gravimetrically by the method of AOAC as outlined by Pearson (1976). The crude protein was determined by the kjedahl method described by AOAC (1997). The protein was calculated using the general factor 6.25 (AOAC). The percentage crude fat (lipid) contents of the samples were determined by the continuous soxhlet lipid extraction method using soxhlet reflux apparatus as outlined by Horowitz (1984) while the percentage carbohydrate contents were estimated as the Nitrogen free extract (NFE) as outlined in AOAC (1997). In this method, the percentage carbohydrate was estimated as the difference between 100 and the sum total of the proximate composition of each sample.

Standard procedures of American Oil Chemist Society were used for lipid indices values as outlined by AOAC (1997). Acid Value (AV) was determined according to the method outlined in ISO 969.17:1997 (AOAC, 1997). The indicator method specified by ISO 3657 in 1988 as outlined by AOAC (1997) was used in the determination of the Saponification Values (SV) of the samples. The Iodine value (IV) was determined by the method specified by ISO 3961 in 1989 as outlined by AOAC (1997). The indicator method specified by ISO 965.33 in 1997 as outlined by AOAC (1984, 1997) was used in the determination of the Peroxide Value (PV) of the samples. The Refractive Index (RI) of the oil samples were determined using a refractometer according to the method outlined by Kyari (2008) while the Specific Gravity (SG) of the oil samples were determined gravimetrically according to the method outlined by Bassir (1971).

Statistical analysis: All extractions and analysis were performed in triplicates. Results were expressed as Mean±Standard Deviation (SD). Data for all determinations were subjected to Analysis of Variance (ANOVA) using Ducan's Multiple Range Test (DMRT) as outlined by Wahua (1999). Fisher's Least Significant Difference (LSD) test was used to identify significant differences among treatment means at $p \leq 0.05$.

RESULTS AND DISCUSSION

The results showed significant differences in the moisture, crude fibre, Ash, lipid, total carbohydrate and calorific values between the two seeds at $p \le 0.05$ using Fisher's Least Significant Difference (LSD). However, the data also show that there is no significant difference in the protein contents of the two seeds at $p \le 0.05$ (Table 1).

Table 1: Proximate composition (%) of coconut (*Cocos nucifera* Linn.) and melon (*Cococynthis citrullus*) seeds

Seed parameter	*Cocos nucifera* (%)	*Colocynthis citrullus* (%)
Moisture	7.51 ± 0.13^b	4.27 ± 0.12^a
Crude fibre	7.70 ± 0.18^b	5.51 ± 0.64^a
Ash	1.02 ± 0.02^a	2.94 ± 0.11^b
Crude protein	10.57 ± 0.63^a	11.67 ± 1.67^a
Lipid	$47^a.80 \pm 0.38^a$	50.42 ± 0.52^b
Total carbohydrate	32.84 ± 0.26^b	29.47 ± 1.68^a
Calorific value (kcal/100 g)	553.99 ± 1.18^a	567.32 ± 4.07^b

Each data is mean of three replicates±Standard Deviation (SD). Figures followed by the same alphabets along the row are not significantly different at $p \le 0.05$ using Ducan Multiple Range Test (DMRT)

Traditional societies have always exploited edible wild plants to provide adequate nutrition, food security and income generation (Akubugwo *et al*., 2008, 2007a, b; Antia *et al*., 2006; Dhellot *et al*., 2006a, b). These wild plants not only provide raw materials for industries but also serve as indispensable constituents of human diet supplying the body with minerals, vitamins and certain hormone precursors, in addition to protein and energy (Akubugwo and Ugbogu, 2007; Fleuret, 1979). The average moisture contents of *C. nucifera* and *C. citrullus* seeds were 7.51 and 4.27%, respectively (Table 1). These values compared favorably with 4.85, 5.21 and 6.10% reported for *Colocynths citrullus* from Akure, *Cucumeropsis edulis* and *Prunus amygdalus* seed flours respectively (Akpambang *et al*., 2008). However, the values were generally lower than 31.6-76.86% reported for *Gnetum africana*, *Telferia occidentalis*, *Mucuna ureans* and *Solanum nigrum* L. var. *virginicum* seeds (Akubugwo *et al*., 2007a; Ekop, 2007). The relative low moisture content of the seeds studied promises a long shelf life for the plant seeds before cultivation.

The crude fibre content of 7.70% obtained for *Cocos nucifera* was higher than 0.8-6.29% reported for most tropical plant seeds in Africa (Akpambang *et al*., 2008; Akubugwo *et al*., 2007a; Ekop, 2007) but lower than 13.3% reported for *Cocos nucifera* Linn. from Akure by Onifade and Jeff-Agboola (2003). The 5.51% crude fiber obtained for *Colocynthis citrullus* seeds compared favourably with that of *Telferia occidentalis* (4.6%) (Ekop, 2007), *Colocynthis citrullus* from Akure (5.0%) and *Prunus amygdalus* (5.7%) (Akpambang *et al*., 2008) and *Solanum nigrum* L. var. *virginicum* seeds (6.29%) (Akubugwo *et al*., 2007a) but was higher than that reported for *Gnetum africana* (0.8%) and *Mucuna ureans* (4.0%) (Ekop, 2007). Adequate intake of dietary fibre can lower cholesterol level, risk of coronary heart diseases, hypertension, constipation, diabetes, colon and breast cancer (Ishida *et al*., 2000; Rao *et al*., 1998). The RDA of fibre for Children, adults, pregnant and lactating mothers are 19-25,21-38, 28 and 29 g, respective (FNB, 2002). This implicates that *C. nucifera* seeds are capable of contributing 31-41, 20-37, 28 and 27% while *C. citrullus* seeds are capable of contributing 22-29, 15-26, 20 and 19% of their respective daily requirements when 100 g of the seeds are consumed. Thus, the seeds could be regarded as valuable sources of dietary fibre in human nutrition. Generally, non-starchy vegetables are the richest sources of dietary fibre (Agostoni *et al*., 1995) and as such, they are employed in the treatment of obesity, diabetes, cancer and gastrointestinal disorders (Saldanha, 1995).

Ash contents which are indices of mineral contents in biota are low, 1.02% for *Cocos nucifera* and 2.94% in *Colocynthis citrullus* (Table 1) compared to the values reported in seeds of *Amaranthus hybridus* var. 1 and var. 2 (4.86 and 4.02%, respectively) (Dhellot *et al*., 2006b), *Solanum nigrum* L. var. *virginicum* (8.05%) (Akubugwo *et al*., 2007a), *Mucnna ureans* and *Telferia occidentalis* (6.0 and 6.9%, repetitively) (Ekop, 2007), *Colocynthis citrullus* from Akure and *Cucumeropsis edulis* (4.48 and 7.0%, respeitively) (Akpambang *et al*., 2008). The values, however, compared favorably with those reported for *Gnetum africana* seeds (1.2%) (Ekop, 2007), *Cocos nucifera* Linn. from Akure (1.19%) (Onifade and Jeff-Agboola, 2003) and *Prunus amygdalus* (3.34%) (Akpambang *et al*., 2008).

The crude protein contents of *Cocos nucifera* (10.57%) and *Colocynthis citrullus* (11.67%) are lower than the protein contents of the seeds of *Gnetum africana* (17.5%), *Solanum nigrum* L. var. *virgrinicum* from Afikpo (17.63%), *Solanum nigrum* L. from Congo Brazzaville (17.04%), *Amaranthus hybridus* var. 1 and var 2 (17.60 and 18.99%, respectively), *Mucuna ureans* (24.33%), *Colocynthis citrullus* from Akure (25.73%) and *Cucumeropsis edulis* (31.81%) (Akpambang *et al*., 2008; Akubugwo *et al*., 2007a, b; Ekop, 2007; Dhellot *et al*., 2006a, b) but higher than values reported for *Telferia occidentalis* (7.0%) (Ekop, 2007). However, the values compared favorably with that of *Cocos nucifera* from Akure (11.22%) (Onifade and Jeff-Agboola, 2003) and *Prunus amygdalus* (14.70%) (Akpambang *et al*., 2008). According to Pearson (1976), plant food that provides more than 12% of its calorific value from protein is considered good source of protein. Therefore, *Cocos nucifera* and *Colocynthis citrullus* seeds that provide 6.56 and 7.08% respectively of their calorific values did not meet this requirement and as such are not rich sources of protein. Furthermore, adults, Children, pregnant and lactating mothers require 13-19, 34-56, 17 and 17 g of protein daily, respectively (FNB, 2002). Assuming complete protein absorption, 100 g DW of *C. nucifera* seeds would contribute 56-81, 19-31, 62 and 62% and *C. citrullus* would contribute 61-90, 21-34, 69 and 69% of their daily requirements, respectively. However, the bioavailability of these proteins to individual subjects is determined by other factors such as genetic factors and the anti-nutritional components of the plant foods (Davidson *et al*., 1975). Plant protein still remain a veritable source of food nutrient for the less privileged population in developing countries, including Nigeria where cost of animal protein is beyond their income per capita (Ekop, 2007). Thus these plant seeds should be incorporated in human and animal nutrition to supplement protein.

Plant seeds are rich source of lipids (Nelson and Cox, 2003; Murray *et al*., 2000). The crude lipid contents of *Cocos nucifera* and *Colocynthis citrullus* (47.80 and 50.42%, respectively) are high compared to reported values of 3.15-34% for most tropical plant seeds in Africa (Akpambang *et al*., 2008; Akubugwo *et al*., 2008, 2007a, b; Kyari, 2008; Akubugwo and Ugbogu, 2007; Ekop, 2007; Dhellot *et al*., 2006a, b) but compared favourably with *Balanites aegyptiaca* (48.3%), *Dacryodes edulis* pulp (43.2%), *Colocynthis citrullus* from Akure (46.24%), *Prunus amygdalus* (42.14%), *Lophira lanceolata* (40%), *Schorocarya birrea* (42%) and *Telferia occidentalis* (50.9%) (Kyari, 2008; Ekop, 2007; Dzondo-Gadet *et al*., 2005). Thus, the plant seeds studied are rich sources of lipids.

The carbohydrate content of 32.84% for *Cocos nucifera* and 29.47% for *Colocynthis citrullus* were higher than 13.70, 12.96 and 17.75% reported for *Colocynthis citrullus* from Akure, *Cucumeropsis edulis* and *Cocos nucifera* Linn from Akure, respectively (Akpambang *et al*., 2008; Onifade and Jeff-Agboola, 2003). These values were, however lower than those reported for *Solanum nigrum* L. var. *virginicum* seed (55.85%) (Akubugwo *et al*., 2007a), *Gnetum africana* (87.62%) and *Mucuna ureans* (61.37%) (Ekop, 2007) but compared favourably with values reported for *Telferia occidentalis* (31.25%) (Ekop, 2007) and *Prunus amygdalus* (28.05%) (Akpambang *et al*., 2008). The Recommended Dietary Allowance (RDA) values of carbohydrate for Children, adults, pregnant and lactating mothers are 130, 130, 175 and 210 g, respectively (FNB, 2002). The results implicate that *Cocos nucifera* will contribute 25, 25, 19 and 16% while *Colocynthis citrullus* will contribute 23, 23, 17 and 14% of the RDA carbohydrate requirement when 100 g of the seeds are consumed by a normal human subject.

The estimated calorific values 553.99 and 567.32 Kcal/100 g in *Cocos nucifera* and *Colocynthis citrullus* seeds respectively are relatively higher than values reported for *Solanum nigrum* L. var. *virginicum* seeds (403.54 Kcal/100 g) (Akubugwo *et al*., 2007a), *Telferia occidentalis* (60.53 Kcal/100 g) *Mucuna ureans* (381.5 Kcal/100 g) and *Gnetum africana* (448.83 Kcal/100 g) (Ekop, 2007). However, the values were in agreement with those reported for dietary and medicinal wild plants in the tropical Africa (Lockeett *et al*., 2000). These values (Table 1) implicated the plant seeds as rich sources of energy.

Table 2 showed the physical properties of oil extracts from *Cocos nucifera* and *Colocynthis citrullus* seeds. The percentage oil yields by soxhlet extraction methods were significantly different from those of the mechanical extraction methods at $p \leq 0.05$ using Fisher's least significant difference. The data showed that *Colocynthis citrullus* seeds yielded more oil than *Cocos nucifera* seeds in both cases. The oil extracts were liquid at 30°C in both extraction methods; however, oils extracted by soxhlet method were pale yellow while those extracted by mechanical methods were yellow in both cases. All the oil extracts had agreeable flavours. The refractive index ranged from 1.432 to 1.465 for *Cocos nucifera* seeds and from 1.466 to 1.471 for *Colocynthis citrullus* seeds. Generally, melon seed oils showed high refractive index values than those of coconut seed oils (Table 2). The results also showed significant differences in the refractive index of oils obtained by the soxhlet and mechanical method for both seeds at $p \leq 0.05$ using Fishers Least Significant Difference (LSD). The specific gravity of

Table 2: Physical properties of oil extracts from coconut (*Cocos nucifera* Linn.) and melon (*Colocynthis citrullus*) seeds

	Cocos nucifera		*Colocynthis citrullus*	
Seed parameter	SEM	MEM	SEM	MEM
Percentage (%) oil yield	47.80±0.38[c]	36.44±0.17[a]	50.42±0.52[d]	44.26±1.03[b]
State at 30°C	Liquid	Liquid	Liquid	Liquid
Colour	Pale yellow	Yellow	Pale yellow	Yellow
Odour	Agreeable	Agreeable	Agreeable	Agreeable
Refractive index	1.465±0.01[b]	1.432±0.05[a]	1.471±0.03[c]	1.466±0.01[b]
Specific gravity	0.88±0.02[a]	0.93±0.03[b]	0.90±0.03[a]	0.92±0.01[b]

SEM: Soxhlet extraction method, MEM: Mechanical extraction method, Each data is mean of three replicates±Standard Deviation (SD), Figures followed by the same alphabets along the row are not significantly different at $p \leq 0.05$ using Ducan Multiple Range Test (DMRT) the oils ranged from 0.88 to 0.93 for *Cocos nucifera* seeds and from 0.90 to 0.92 for *Colocynthis citrullus* seeds. There were significant differences in the specific gravity of the oils obtained using soxhlet and mechanical extraction methods for both seeds at $p \leq 0.05$ using Fisher's LSD.

The refractive index of the oils ranged from 1.432 for mechanical extracted *Cocos nucifera* seed oil to 1.471 for soxhlet extracted *Colocynthis citrullus* seeds oil. These values are within the range of refractive indices reported for *Butyrospermum parkii* (1.453), *Lophira lanceolata* (1.459), *Sterculia setgera* (1.465), *Detarium microcarpum* (1.465), *Blighia sapida* (1.449) and *Schorocarya birrea* (1.422) (Kyari, 2008) and as well as seeds oils from Akure, *Colocynthis citrullus* (1.47), *Cucumeropsis edulis* (1.47) and *Prunus amygdalus* (1.47) (Akpambang *et al*., 2008). The specific gravity of the oils is 0.88 and 0.93 for soxhlet and mechanical extracted *Cocos nucifera* seeds oils respectively and 0.90 and 0.92 for soxhlet and mechanical extracted *Colocynthis citrullus* seeds oils, respectively. These values compared favourably with the range of specific gravities, 0.81-0.928 reported for other oils, fats and waxes from some common plant seeds in Nigeria (Akubugwo *et al*., 2008; Akubugwo and Ugbogu, 2007; Yusuf *et al*., 2006; Ajayi and Oderinde, 2002; Badifu and Ogunsua, 1991; Kamel *et al*., 1985). However, the values were low compared to those reported for seeds from Akure, *Colocynthis citrullus* (1.51), *Cucumeropsis edulis* (1.67) and *Prunus amygdalus* (1.71) (Akpambang *et al*., 2008). All the physical properties observed for the oils were in agreement with those recommended by Codex Alimentarius Commission (1982) and as such indicate edibility.

The chemical properties of oils extracted from *Cocos nucifera* and *Colocynthis citrullus* seeds as compared to those commercial available oils in the Nigerian market are shown in Table 3. The acid values ranged from 2.06 mg NaOH g^{-1} for soxhlet extracted coconut oils to 25.6 mg NaOH g^{-1} for palm kernel oil, the free fatty acid. ranged from 1.03% for soxhlet extracted coconut oil to 12.81% for palm kernel oil, the saponification values ranged from 152.87 mg KOH g^{-1} for Filma oil to 258.76 mg KOH g^{-1} for palm kernel oil, the lodine values ranged from 9.93 mg of I g^{-1} of oil for soxhlet extracted coconut oil to 121.03 mg of I_2 g^{-1} of oil for palm kernel oil while the peroxide values ranged from 0.21 meq O_2 kg^{-1} for both soxhlet and mechanical extracted coconut oils to 2.72 meq O_2 kg^{-1} for mechanically extracted melon seed oils.

The data (Table 3) showed significant differences in the acid values, free fatty acids, saponification values, lodine values and peroxide values of the oils at $P \leq 0.05$ using Ducan Multiple Range Test (DMRT). However, there were no significant differences in the acid values and free fatty acids between Soyabean and Filma oils, Gino and Wangasa oils, Turkey and Kings oils and between mechanically extracted coconut and melon seed oils. Also, the data showed no significant differences in the saponification values between Filma and Gino oils, Turkey and Kings oils, Soyabean and Kulikuli oils, Controller and melon seed oils and between mechanically extracted coconut oil and palm kernel oils. The results (Table 3) also showed that there were no significant differences in the lodine values between soxhlet and mechanically extracted coconut seed oils, Turkey and Wangasa oils, kings and Soyabeans oils, Controller and palm kernel oils and among melon seed oils, Kulikuli and Gino oils and as well as no significant differences in the peroxide values between coconut and palm kernel oils,Wangasa and kings oils, soxhlet extracted melon seed oils and kulikuli and among Soyabean, Filma and Gino oils at $p \leq 0.05$ using Ducan Multiple Range Test (DMRT).

Table 3: Chemical properties of the oils extracted from *Cocos nucifera* and *Colocynthis citrullus* seeds as compared with those from commercial available oils in the Nigerian Market

Chemical properties oil sources	Acid values (mg NaOH g^{-1})	Free fatty acids (%)	Saponification values (mg KOH g^{-1})	Iodine values (mg of 1 g^{-1} of oil)	Peroxide values (meq O_2 Kg^{-1})
Cocos nucifera (SEM)	2.06 ± 0.32^{a}	1.03 ± 0.16^{a}	252.44 ± 1.39^{g}	9.73 ± 0.48^{a}	0.21 ± 0.01^{a}
Cocos nucifera (MEM)	6.36 ± 0.32^{g}	3.18 ± 0.16^{g}	257.59 ± 2.14^{h}	10.99 ± 0.73^{a}	0.21 ± 0.01^{a}
Colocynthis citrullus (SEM)	2.99 ± 0.19^{b}	1.49 ± 0.06^{b}	196.82 ± 0.82^{f}	110.93 ± 0.66^{f}	1.53 ± 0.01^{f}
Colocynthis citrullus (MEM)	6.17 ± 0.56^{c}	3.09 ± 0.28^{fg}	201.03 ± 0.81^{f}	111.46 ± 0.18^{f}	2.72 ± 0.02^{g}
Rapesees	3.74 ± 0.23^{c}	1.87 ± 0.01^{c}	174.84 ± 0.18^{c}	107.87 ± 0.81^{e}	0.50 ± 0.01^{d}
Soya bean	4.30 ± 0.02^{d}	2.15 ± 0.05^{d}	192.45 ± 2.21^{e}	97.29 ± 0.40^{c}	0.37 ± 0.01^{c}
Wangasa	4.86 ± 0.03^{e}	2.43 ± 0.16^{e}	186.53 ± 0.04^{d}	86.39 ± 1.07^{b}	0.28 ± 0.02^{b}
Kulikuli	12.53 ± 0.56^{i}	6.26 ± 0.61^{i}	194.95 ± 0.14^{e}	111.99 ± 0.63^{f}	1.60 ± 0.10^{f}
Kings	5.80 ± 0.25^{f}	2.92 ± 0.57^{f}	169.70 ± 0.03^{b}	94.43 ± 0.48^{c}	0.29 ± 0.02^{b}
Turkey	5.61 ± 0.06^{f}	2.81 ± 0.08^{f}	166.89 ± 1.40^{b}	82.17 ± 0.63^{b}	0.31 ± 0.01^{b}
Filma	4.45 ± 0.50^{d}	2.23 ± 0.07^{d}	152.87 ± 0.43^{a}	102.58 ± 1.20^{d}	0.38 ± 0.01^{c}
Cimo	4.85 ± 0.32^{e}	2.43 ± 0.67^{e}	153.34 ± 0.79^{a}	113.89 ± 0.32^{f}	0.39 ± 0.02^{c}
Palm Kernel Oil (PKO)	25.62 ± 0.29^{j}	12.81 ± 0.16^{j}	258.76 ± 1.22^{h}	127.03 ± 0.89^{g}	0.23 ± 0.02^{a}
Controller	6.73 ± 0.56^{h}	3.37 ± 0.21^{h}	196.35 ± 0.41^{f}	118.76 ± 0.66^{g}	1.13 ± 0.07^{e}

*SEM: Soxhlet extraction method, *MEM: Mechanical extraction method, *Each data is mean of three replicates±Standard Deviation (SD), *Figure followed by the same alphabets along the column are not significantly different at $p \leq 0.05$ using Ducan Multiple Range Test (DMRT)

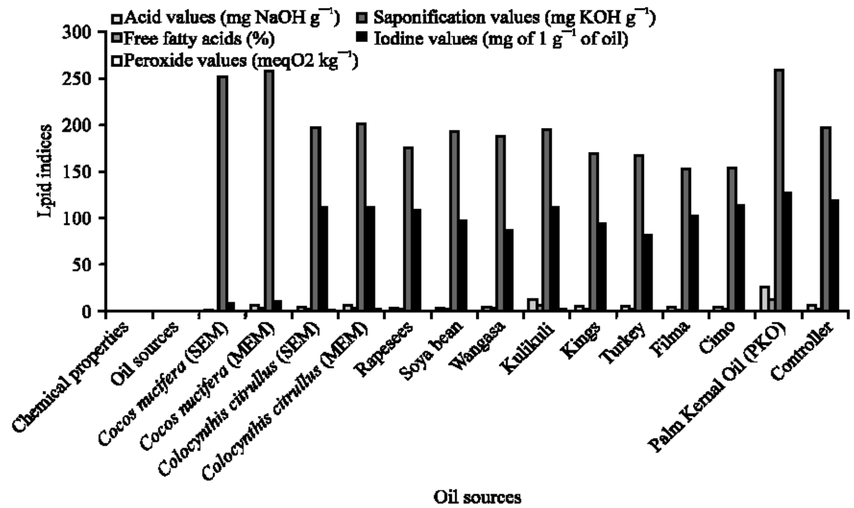

Fig. 1: A comparative assessment of *Coco nucifera* and *colocynthis citrullus* seed oils relative to commonly commercial available oils in the Nigerian Market

The acid values of the seed oils compared favourably with the range, 1.20-8.41 mg NaHg^{-1} reported for *Telferia occidentalis*, *Citrillus vulgaris*, *Colocythis citrullus* (from Akure), *Pentaclethra macrophylla* and *Treculia africana* (Akpambang *et al*., 2008; Akubugwo *et al*., 2008; Yusuf *et al*., 2006) and that of most conventional oils (Rapeseed, Soya bean, Wangasa, Kings, Turkey, Filma, Gino and Controller oils) sold in the Nigerian market (Fig. 1). However, these acid values are lower than that reported for *Persea gratesima* (11.46 mg NaOH g^{-1}) and *Cocos nucifera* (11.31 mg NaOH g^{-1}) from Isiala Ngwa (Akubugwo *et al*., 2008), *Cucumeropsis edulis* (9.36 mg NaOH g^{-1}) and *Prunus amygdalus* (9.66 mg NaOH g^{-1}) (Akpambang *et al*., 2008) and as well as some conventional oils (Kulikuli and Palm Kernel oil) sold in the Nigerian market (Fig. 1) but higher than the range, 0.034-0.540 mg NaOH g^{-1} reported for *B. parkii*, *L. lanceolata*, *S. setegera*, *D. microcarpum*, *B. sapida* and *S. birrea* (Kyari, 2008). Acid value is used as an indicator for edibility of oil and suitability for use in the paint industry. The acid value of the seed oils studied fell within allowable limits for edible oils (Codex Alimentarius Commission, 1982). Therefore, the oils are edible. The seed oils generally had low acid values and corresponding low levels of free fatty acid in the oils which suggests low level of hydrolytic and lipolytic activities in the oils. Thus, the seed oils studied could be good sources of raw materials for industries.

The saponification value is in the range of 252.44-257.59 mg KOH g^{-1} for *Cocos nucifera* and 196.82-201.3 mg KOH g^{-1} for *Colocynthis citrullus* seeds. These ranges conform to those reported by numerous authors (Akubugwo *et al*., 2008; Kyari, 2008; Yusuf *et al*., 2006; Kapseu and Parmentier, 1997; Codex Alimentarius Commission, 1982) for other plant seeds and most conventional oils sold in the Nigerian markets (Fig. 1). The ranges are however, higher than those reported for *Detarium microcarpum* (123.3 mg KOH g^{-1}), *Persea gratesima* (106.60 mg KOH g^{-1}), *Telferia occidentalis* (158.40 mg KOH g^{-1}), *Solanum nigrum* L. (157.3-190.1 mg KOH g^{-1}) and *Amaranthus hybridus* var. 1 and var. 2 (147.9-185.6 mgKOHg^{-1}) (Akubugwo *et al*., 2008; Kyari, 2008; Dhellot *et al*., 2006a, b) and as well as some conventional oils in the Nigerian markets (Fig. 1). The relative high saponification value recorded for all the seed oils is indicative that they have potentials for use in the industries especially in soap manufacturing industries (Kyari, 2008; Amoo *et al*., 2004).

The iodine value is in the range of 9.73-10.99 for *Cocos nucifera* and 110.93-111.46 for *Colocynthis Citrullus* (Table 3). The iodine value of 9.73-10.99 for *Cocos nucifera* confirms the value of 9.60 reported in the literature (Akubugwo *et al*., 2008) and it is higher than 2.65-3.45 reported for *Colocynthis citrullus*, *Cucumeropsis edulis* and *Prunus amygdalus* (Akpambang *et al*., 2008) but lower than those reported for most non-conventional plant seeds in Nigeria and Congo Brazzaville (Akubugwo *et al*., 2008; Kyari, 2008; Dhellot *et al*., 2006a, b) and as well as those obtained for the conventional oils in the Nigerian markets (Fig. 1). The iodine value of 110.93-111.46 for *Colocynthis citrullus* (Table 3) compared favourably with the values obtained for all the studied conventional oils in the Nigerian markets (Fig. 1) and also with the literature values for

Solanum nigrum L. (102.8-103.25) and *Amaranthus hybridus* var. 1 and 2 (109-112.92) from Congo Brazzaville (Dhellot *et al*., 2006a, b) and *Telferia occidentalis* (114.0) and *Ciltrillus vulgaris* (114.5) from Abeokuta (Yusuf *et al*., 2006). The value was however, higher than most non-conventional seed oils reported in literature (Akpambang *et al*., 2008; Akubugwo *et al*., 2008; Kyari, 2008). A good drying oil should have Iodine value of 180 and above (Codex Alimentarius Commission, 1982). Thus, the values obtained for these seed oils classify them as non-drying and as such the seed oils will not be suitable as alky resins for paint formulation or use as varnishes; they may however, found uses in conjunction with amino resins as finishes for certain appliances and in this case, the oils can act as plasticizers. The relative low iodine numbers of the seed oils may be indicative of the presence of few unsaturated bonds and low susceptibility to oxidative rancidity (Eka, 1980).

The peroxide value is 0.21 for *Cocos nucifera* and 1.53-2.72 for *Colocynthis citrullus* (Table 3). These values compared favorably with the range 0.39-7.4 reported for non-conventional seed oils in Nigeria and Congo Brazzaville (Akpambang *et al*., 2008; Akubugwo *et al*., 2008; Yusuf *et al*., 2006; Dhellot *et al*., 2006a, b) and the range, 0.23-1.60 obtained for the studied conventional oils in the Nigeria Markets (Fig. 1). The values were however, lower than 77.5, 95.0, 35.0, 150.0, 135.0 and 25.0 reported for *B. parkii*, *L. lanceolata*, *S. setegera*, *D. micorcarpum*, *B. sapida* and *S. birrea*, respectively (Kyari, 2008). Peroxide values are used as indicators of deterioration of oils. Fresh oils have peroxide values less than 10 meq O_2 kg^{-1} (Codex Alimentarius Commission, 1982) while values above 20 indicate rancid taste and disagreeable odour (Pearson, 1976). The low peroxide value of these seed oils are indicative of low level of oxidative rancidity of the oils and also suggest the presence or high levels of antioxidant.

CONCLUSIONS

The proximate composition, extraction, characterization and comparative assessment of *Cocos nucifera* and *Colocynthis citrullus* seeds and seed oils were evaluated in this study. All the seeds examined were shown to be nutritionally potent with appreciable high levels of nutrients and energy. Thus, the seeds could be good sources of food supplement for human nutrition and animal feeds. The seeds were also shown to contain high levels of good quality oil whose characteristics compared favourably with most conventional vegetable oils sold in the Nigerian markets. The seed oils had agreeable colour and odour and were all liquids at room temperature (30°C).

The lipid indices of the seed oils showed that they are edible oils judging by their low acid values and their corresponding low free fatty acids levels suggested low hydrolytic and lipolytic activities in the oils. Industrially, the results revealed the seed oils as having great potentials in soap manufacturing industries because of their high saponification values and as such, the seed oils could be commercialized for such purposes. The seed oils are non-drying due to their low Iodine values, however, this also suggest that they contain few unsaturated bonds and therefore have low susceptibility to oxidative rancidity as confirmed by there are peroxide values.

Although the oils are non-drying and as such not suitable as alkyl resins for paint formulation, they may however, find a suitable place in other numerous industrial applications because of the presence or high levels of anti-oxidants in the oils judging by their low peroxide values which also suggested that the oxidative rancidity and deterioration of the seed oils are minimal.

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