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Properties and Industrial Potential of Walnut Growing in Nigeria

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Abstract
African walnut (*Tetracarpidium conophorum*) is one of the underutilised plant species in Nigeria. It is often found growing wild as a climber in the forest region of Africa and India. The vine is mostly found between 4° 15^N and 8^N of the equator where it is usually cultivated by subsistence farmers. The fruit is a very good source of vitamins A, B, B2, B6 and E and of minerals, such as foliate, sodium, potassium, manganese, copper, chloride, iron and ascorbic acid. The immature fruit is a good source of vitamin C. The nut is a good source of carbohydrate (16.9%) and calories of about 600J. The protein content ranged between 3.1% - 43.1%. It is an excellent source of polyunsaturated acids such as alpha linolenic acid (ALA) and an excellent source of anti-inflammatory omega 3 essential fatty acids. The oil content is very high at about 60%. The nuts which contain uncommon fatty acids are used in protective coatings, dispersants, pharmaceuticals, cosmetics and a variety of synthetic intermediates. It is also used as stabilizers in plastic formulations. It is very rich in ascorbic acid. The oil is good for soap making and it competes favourably with edible oils. Alkyd resins produced from walnut oil compared with commercial alkyd resin as its film air dried within a few hours and show chemical resistance to various solvent media such as water, brine and acid. The plant also has a number of health benefits. Photochemical analysis of the nuts, leaves and roots showed that they contain bioactive compounds such as oxalates, phytates, tannins, saponins, alkaloids, flavonoids and terpenoids and are used in wound healing, disease prevention and as anticancer agents. The development of walnut for industrial use locally will save the nation about US$200 million annually apart from providing employment for the citizens. It will also act as a vehicle for poverty alleviation.
Keywords: Walnut, Sodium, Potassium, Oil, Monosaturated Fats.

1.0 Introduction

The renewed resurgence for the development of formally unknown and underutilised plant species globally is predicated on three major objectives. One, is the need to expand the base of industrial raw materials as many underutilised plant species are very specific in their properties and therefore, very difficult to be substituted by synthetic products. Another important reason is that no raw material, most especially in the oilseeds category is equally suitable for all purposes since each one has its unique characteristics. Third, all modern crop varieties were originally produced using land races developed by farmers from wild plants over hundreds and thousands of years. The wild relatives still represent reservoirs of genes that are essential for improving crops or developing new strains to keep them from being overwhelmed by stresses such as changing climate or evolution of new pests, parasites and diseases.

Currently, across the globe, many of the plant species that are now cultivated for food were initially neglected and underutilised (Magbagbeola *et al.*, 2010). Some of these are potential industrial raw materials and can serve as precursors of new products (Ogunwusi, 1992). According to IIED (2000), an estimated 4% of global economy is based on biological products and processes. The development of underutilised plant species of high industrial potential will substantially increase the contribution of biological products to global economy (Ogunwusi, 1992).

One of the intrinsic underutilised plant species in Nigeria is the African walnut (*Tetracarpidium conophorum*). The African walnut is often found growing wild as a climber in the forest regions of Africa and India (Edem *et* al., 2009). In Nigeria, it is predominantly found in the Southwest States. It is commongly reffered to as African walnut because of its West African origin. It is known as Ekporo by Efik and Ibibios of Cross River and Akwa Ibom, as Ukpa in Ibo, Awusa or Asala in Yoruba, Okwe in Edo and Gwandi bairi in Hausa (Akupuaka and Nwanko, 2000). While the plant is mostly maintained by cultural preferences and traditional practices, it remained inadequately characterised and neglected by research and conservation. This made its potential value to be underestimated, undervalued and underexploited. It also places the plant in danger of genetic erosion and disappearance which have the potential to restrict its development options (Dansi *et al.* 2012). Also, the focus on a few widely used species to the detriment of most underdeveloped plant species has narrowed down dramatically the number of species upon which global food security, industrial, economic and general agricultural development depends (GFAR, 1999). This paper examines the production, nutrient composition and industrial properties of African walnut and its potential role in contributing to national industrial development and value added exports from Nigeria.

2.0 Production of Walnut in Nigeria

Tetracarpidium conophorum (mul. Arg.) is from Euphorbiaceae family and commonly called African walnut (GRIN, 2010). It is a perennial climber found in moist forest zones of sub-sahara Africa (Oke, 1995). The vine is mostly found between 4° 15'N and 8°N of the equator. The wild fruit is grown in traditional farming systems of lowland humid region. It is usually about 6 – 18cm long on attainment of productive phase (Junik and Paul, 2008). It is usually cultivated by small subsistence farmers in the hot and humid zones of tropical Africa in compound gardens and backyards just for the family and local market consumption. They are found both in primary and secondary forests. In Nigeria conophol plants flowers between November and early January and fruits between January and September with peak production in July. The immature fruits are usually green in colour but turn dark brown as they mature (Oluwole and Okusanya, 1993). The fruit is a four winged ribbed capsule, containing subglobose seeds with a thin brown and yellow kernel. Each seed is about 2.5cm in diameter. The fruit (7cm across) are light green to brown when ripe while the seeds are round dark brown at maturity. Sometimes, not all the seeds developed in case the fruit has fewer wings (Kanu and Okorie, 2015). The fruit is a capsule 6 - 10cm long by 3 - 11cm wide containing globular seeds 1 - 2.5m long with a thin shell resembling temperate walnut.

The natural area where the vine is found is the forest, but due to high predation in this ecosystems, it is not easy for farmers to harvest the fruit from there. This is why farmers decide to plant the vines in their agroforests where it is more secure.

Small scale farmers constitute the highest producers of walnut (Babalola, 2016). According to Babalola (2016), the male gender are in charge of the production sector of African walnut while the female were mostly involved the processing of the nuts. While the quantity of walnuts produced on annual basis cannot be ascertained, it is important to stress that the sale of cooked walnut seed add to the farmers income (Babalola, 2016).

In the Southwest of Nigeria, *T. conophorum* is cultivated on cocoa, kola, oil palm and orange farms by about 81.7% of the farmers (Babalola, 2016). Several authors (Sonwa, 2004; Bobo *et al.,* 2006; Laird, 2007) have indicated the relative abundance of African walnuts in cocoa ecosystems in West Africa. This classify it among specific peasant choice in terms of species associated with cocoa agroforests. It is principally cultivated for its nuts that are cooked and consumed mainly as snacks (Oke, 1995; Victor, 2003; Edem, *et al.*, 2009). The plant is cultivated under an indigenous tree that can provide strong support for the heavy weight of the climber when fully established on the crown of the tree. A planting density of 5 stems/ha was found in Nigeria forest area (Ndaeyo, 2007) and abundances of 0.03 and 0.06 respectively have been reported in the primary and secondary. The forest ecosystem is a relatively closed ecosystem and many trees suffer from remarkable light problem and tend to die (Kemueze *et* al., 2009). The climber takes over the crown of the host tree when fully established; (Babalola, 2016). In view of this, trees that do not produce high economic fruits are mostly used to serve as support for the climber. Despite the negative role the plant play on its hosts, the impact is negligible as the vine plays important role in cocoa plantation which do not need light to grow. Peasants does not use shrubs as hosts but old, mature trees to support the vine and to create shade in the farm. This explains the choice of mangoes and plum trees as hosts. Besides its food and medicinal potential, (Jiofack, 2003), this liana, during growth extend its branches and wraps trees or hosts up, to finally create shade which is favourable to cocoa plantation (Jiofack *et al.,* 2012 phone). The fully grown plants can attain a diameter of up to 17cm. A major hindrance to the improved production of African walnut is unavailability of planting materials. Nurseries of the plant are few and scarce and the planting materials cannot be obtained in the open market (Ouya, 2013).

2.1 Nutritional Composition and Nutritional Value

Several studies have indicated that walnut is rich in protein, fat and carbohydrate but low in fibre and ash contents. According to Kanu and Okorie (2015), the nuts have also been found to be very good sources of Vitamins A, B_1, B_2, B_6, E, folate, sodium, potassium, manganese, copper, chloride, iron and ascorbic acid. The green hulls or the immature fruits are good sources of vitamin C. The nut is a good source of energy being a good source carbohydrate (16.9%) and calories of about 600J. The value of protein content of *T. conophorum* fall within the range of 3.2 – 43.1% for fruits and nuts. Any plant food that provides more than 12% of its energy from protein is considered a good source of protein (Kanu and Okorie, 2015. It is an excellent source of polyunsaturated fatty acids such as alpha-linolenic acid (ALA). The nuts of *T. conophorum* is an excellent source of anti-inflammatory omega-3 – essential fatty acids. In terms of phytonutrients, walnuts contain antioxidants and antiinflammatory compounds including more than a dozen phenolic acids, most especially, elligatannis, antitellimagrandins and a wide variety of flavinoides. It also contain a very high composition of vitamin E, most especially, gamma-tocophenol.

3.0 Industrial Properties of African Walnut

There is a wealth of information on the potential of walnuts as major sources of fat, minerals, proteins and

vitamins (Okoye and Okobi, 1984; Ihemeje, *et al*., 2012). Generally, nuts are far richer than meat (Ihemeje, *et al*., 2012). The nuts contain uncommon fatty acids which are industrially important as they are used in protective coatings, dispersants, pharmaceuticals, cosmetics and a variety of synthetic intermediates as stabilizers in plastic formulations (Hosamani and Sattigeri, 2003). It contains monosaturated fats (15%). Other fatty acid compositions of the nut oil include palmitic, palmitoleic, arachidic and eicosenic acids. It is very rich in ascorbic acid and could be used to boost ascorbic acid content of most food products.

Walnut is one of the high density foods with the presence of oxalates, phytates, tannins as well as protein, fibre, carbohydrates, and vitamins (Savage *et al*., 2001). Walnut is a good source of mineral elements such as calcium, magnesium, sodium, potassium and phosphorus (James, 2009). Walnut kernel generally contain about 60% of oil (Prasad, 2003), however, this varies from 52% to 70% depending on cultivar, location grown and irrigation rate (Ozkan and Koyuncu, 2005).

In a study reported by Isong *et al* (2013) on the physico-chemical properties of African walnut oil, the oil content obtained was observed to be relatively high at 57.50% (Table 1). The moisture content of the walnut oil was observed to be only 1.59% which indicated that it can be preserved for a long time. The specific gravity obtained from the study was reported to be 0.9g/cm indicating that the oil is less dense than water while the saponification value was 176.87mg $KOHg^{-1}$ (Osita, 2007) and 213mg $KOHg^{-1}$ in neem seed oil (Akpan, 2000) but higher than 159.33mg $KOHg^{-1}$ reported for Dementia tripatala fruit oil (Ikhuoria and Maliki, 2007). According to Isong *et al* (2013), this indicated that the oil is good for soap making since its saponification value falls within the range of oils currently used for the same purpose. The iodine value was reported to be 7.31gl $100g^{-1}$ indicating that walnut oil is a suitable material for paint production. The value obtained for free fatty acid at 9.47% indicated that it is edible as a low free fatty acid content of oils indicated its susceptibility to rancidity (Isong *et al*., 2013).

In general, Isong *et al* (2013) concluded that walnut oil compares favourably with existing oils and it is similar to other edible oils. It can also be used for domestic cooking and in soap and paint industries. It was also observed that the biofuel potential could be explored and improved on.

In another study on the evaluation of the performance characteristics of walnut seed oil-modified alkyd resin, Momodu *et al* (2011) reported that walnut seed oil produce alkyd resins whose coating properties are comparable with those of commercial alkyd resin, as its film air-dried within a few hours and shows chemical resistance in various solvent media such as water, brine and acid. The physico-chemical properties of the oil presented in Table 2 show the iodine value to be 153.05 which classified it as a dry oil which is an important requirement in alkyd resin synthesis. The saponification value at 203.45 reveals the average molecular weight of the fatty acids of triglycerides present in the walnut.

Currently in Nigeria, the oils mostly employed for alkyd resin synthesis are linseed, soyabean, castor and tall oil (Oguniyi and Njikang, 2000; Kildiran *et al*., 1996; Majumder, 1999). The oils are largely imported for the formulation of coatings of metal cans used in packing of beverages, drugs, food, etc. The production of this oil locally will reduce expenditure of foreign exchange on their importation.

3.1 Medicinal Value of *T. conophorum*

Walnuts have innumerable health benefits. The seed has a number of uses ranging from weight management to prevention and slowing of various cancers. The plant has innumerable benefits as phytochemical analysis of the nuts, leaves and roots indicated that it has bioactive compounds such as as oxalates, phytates, tannins, saponins, alkaloids, flavinoids and terpenoids (Kalu, 2010; Ayodele, 2003; Onawumi, 2013; Ayoola *et al.,* 2011; Onawumi *et al.,* 2013). Research has indicated that the skin has about 90% phenols tannins and flavonoids which gives it its slight bitterness compared with other nuts, which typically contain a high amount of monounsaturated fats. Walnuts are unique as the fats are primarily polyunsaturated fatty acids (PUFAs) and it is the only nut with a significant amount of alpha-linolenic acid. It also has an insignificant amount of cholesterol free sodium. In Nigeria, walnut seeds are used in the treatment of fibroid (NNMDA, 2014). The juice from the leaves when taken mitigate prolonged hiccups. The seeds are used in Nigeria to increase sperm counts in men while the leaf juice is used to improve fertility in women and to regulate menstrual flood (Obayendo, 2013). Specific potential of walnut application in medicine are discussed below:

3.2 Wound Healing Activity

Studies have shown that *T. conophorum* possess some properties that are required for wound healing like antibacterial, antioxidant and immune stimulating activities (Kanu and Okorie, 2015) . Wound healed faster in wounds treated with 5% and 10%. *T. conophorum* or gentamicin within 8 days compared to rats treated with pure ointments (Ezealisiji *et al,* 2014). When compared to standard groups the percentage wound contraction on day 4 for 10% n-hexane group was significant, while no significant ($p<0.05$) different was observed in the wound contraction activity of other groups below the 16^{th} day. The percentage mean wound contractions on day 18 were 69.18, 84.14, 90.60, 88.36, 96.50 and 98.09 respectively for the negative control, 50% n-hexane, 10% n-

hexane, 5% methanol, 10% methanol and gentamicin respectively (Ezealisiji *et al,* 2014). Many make up and skin care brands include walnuts in their ingredients while a number of shampoos contain walnut extracts and oil.

3.3 Antioxidant Activity

In a study reported by Akomolafe *et al* (2015) the anti-peroxide activity of the leaves of *T. conophorum* was observed to reduce malondialdehyde (MDA) level in reproductive organs and accessory glands of rats. Adult male rats were administered orally with the aqueous leaf extract from *T. conophorum* at 50, 500 and 1000mg/kg body weight for 21 consecutive days while clomiphene citrate (1.04mg/kg body weight), a fertility drug was used as standard. The results of the study indicated that there was increase in relative organ weight, body weight, mean total food and water consumed by the treated groups. According to Kanu and Okorie (2015), the results suggest that the extract from *T. conophorum* leaves had greater capacity to reduce lipid peroxidation in reproductive organs and accessory glands. Thus, the plant may be useful in the treatment/management of reproductive cellular damage.

3.4 Disease Prevention Activity

Omega 3 and Omega 6 are two essential fatty acids required by the body for cell growth, immune function, blood clotting and disease prevention which the body cannot make on their own. These fatty acids are supplied by walnuts. The body needs requires two critical Omega-3 fatty acids (eicosnpentaennic acid called EPA and docosa hexaenoic acid called DHA). Walnut contains a precursor Omega-3, called apha-linoleic acid (ALA) which coverts EPA and DHA. About 28g of walnuts provides 18g of total fat of which 13g are PUFA and 2.5g are ALA (NW, 2014).

3.5 Antihyperglycaemic Activity

Studies by Onwuli *et al* 2014 indicated that *T. conophorum* nut have antihyperglycaemic effect. In the study reported by Kanu and Okorie (2015), rats were grouped into five groups (A – E) of four rats each. Diabetes was induce in the rats except for group which served as positive control. Group B (negative control), C, D and E contained diabetic rats each with blood sugar level >17.00mmol/L. Groups A and B were fed on 85.2g of top feed grower over the test period. Test groups C, D and E were fed on 21.3g, 42.6g and 85.2g of walnuts respectively and their fasting blood glucose levels of the test groups were significantly lower than negative control $P<0.05$ for 3rd, 7th and 10th days of the test. There was also significant increase in the body weight and haemoglobin concentration and a decreased urine output of the test group compared with the controls.

3.6 Pregnancy Protection and Sperm Quality Improvement

Walnut stave off nausea during pregnancy and boost brain development in the child. Harvard School of Public Health Nutritionists reported that consumption of peanuts and tree nuts during pregnancy might decrease the risk of allergic disease development in children (NW, 2014). Likewise, researchers from UCLA reported that consumption of about 75g of walnut could help improve sperm quality due to the alinoleic acid and Omega-3 that it contains. These boosts sperm vitality, mobility and morphology.

3.7 Anticancer Activity

Research has indicated that walnut has anticancer activities. The antioxidant properties of walnut help lower the risk of chronic oxidative stress, and the anti-inflammatory properties help chronic oxidative stress inflammation. Studies indicated that the risk prostrate and breast cancer are reduced by walnut intake (Pharmanews, 2016).

3.8 Weight Management Activity

A research published by Journal of Obesity indicated that walnut could improve weight loss and keep weight off for a longer period than following a low fat diet. An ounce of walnut contains 2.5g of Omega-3 fats, 4g of protein and 2g of fibre that provide satiety. This assists in weight management program as satiety is an important factor in weight management plan (NW, 2014).

3.9 Antichelating Activity

Kanu and Okorie (2015) reported that *Tetracarpidium conophorum* extract may be explored in the industrial production of iron chelators due to its high chelating ability in vitro at low doses, which will be of clinical relevance in the treatment of iron overload disorders such as thalessema, a group of genetically inherited blood disorders characterised by defective globin chain of haemoglobin and iron overload. According to Kanu and Okorie (2015), a study conducted by Olabinri *et al* (2010) assessed the vitro chelating ability of aqueous extract of *T. conophorum*. The plant extract showed a dose dependent decrease in chelating ability in citro. The values of chelating ability for graded doses (2%, 4%, 6%, 8% and 10% $^{w}/_{v}$) were 97.38, 90.56, 89.00, 87.46 and 82.80 respectively. The dose (2%, $^{w}/_{v}$) had the highest chelating ability. At 8% concentration, a strong positive

significant correlation was observed between chelating ability and total phenolics concentration (r = 0.89; p = 0.01). At 2% concentration, the chelating ability of the extract showed a high positive significant correlation with antioxidant activity (r = 0.68; p = 0.001).

3.10 Anticholesterol Activity

Recent studies have shown that approximately an ounce of walnuts daily over a period of 2-3 months can help reduce metabolic syndrome related problems (Pharmnews 2016). The addition of walnut to diets decreased abdominal adiposity (Pharmnews, 2016). The ability of *T. conophorum* to reduce cholesterol seems to be the heart of their health benefits. Also, in a research reported by Kalu and Okorie (2015), it was discovered that male Sprague Dawley rat fed with a standard, commercial diet (control group) or a diet containing *T. conophorum* oil for 60 days reduced the level of cholesterol and triglyceride in the rats compared with the control group fed with standard diets. Also, studies carried out in the United States, Australia, New Zealand, Spain, Israel indicated that consuming 2 – 3 serving of walnut daily decreases cholesterol levels sufficiently to low the risk of coronary heart disease (CHD).

3.11 Other Health Benefits

The consumption of walnuts has been reported to assist in the treatment of Type 2 diabetics. Treatment of people with Type 2 diabetics has shown increased flexibility in the response of cardiovascular system following meals consisting of walnut. A variety of different measurements on blood vessels and measurement of ultrasound show a relatively small amount of daily intake of walnut (1-2 ounces) to provide significant benefits for persons with type 2 diabetes by reducing low density lipoprotein (Pharmanews, 2016). Also it has also been observed that the anti-inflammatory nutrients in African walnuts play a special role in support of bone health. The antioxidant properties of African walnut help lower risk of chronic oxidative stress and the anti-inflammatory properties help lower risk of chronic inflammation and it is precisely these two types of risk when combined, pose the greatest threat for cancer development. *T. conophorum* extracts which are rich in dietary Omega-3 fatty acids may play a role in the prevention of some disorders including depression as well as dementia especially Alzheimer's disease. Apart from these, the anti-inflammatory nutrients in walnuts have been observed to play a special role in support of bone health. According to Pharmanews (2016), studies have shown that large amounts of walnuts decrease blood levels of N-telopeptides of type I collage (NTx) which are good indicators of bone turnover. The decreased blood level in response to walnut intake is an indication of bone stability and less mineral loss from bone.

4.0 Socio-Economic Importance of Walnut in Nigeria

The walnut has not been fully developed for industrial utilisation in Nigeria. According to Babalola (2012), neither the producers nor the marketers engaged in direct sale of the product. The village merchant moves from village to village and market to market to buy the available raw nuts (Babalola, 2012). The buck of walnuts are consumed in the city, therefore the village merchants transport the product to the wholesalers in the cities and towns for onward distribution to the retailers. A high selling price is obtained by both producers and marketers where there is less quantity of the product in the market. Despite its current low industrial application, Onwualu (2013) stipulated that tiger nut and walnut can fetch Nigeria over ₦100 billion annually and create direct employment for over 5,000 people, if the value chain for production, handling, processing and marketing of the commodities are properly developed.

The prospects for developing export market for African walnut is also high. According to Onwualu (2013), there is high market for walnut as the United States imported shelled and dried walnuts valued at $5.6 million in 2012 alone. To enhance increase productivity of walnut and development of its value chain in Nigeria, it is important that small scale farmers at the local level which constituted the producers be encouraged through necessary inputs in order to promote full scale production and exploration of its potential. Despite the current low productivity however, the socio-economic contributions of African walnut to farmers and other stakeholders can be seen as an opportunity to conserve indigenous trees under which it grown (Babalola, 2012). In Yaounde, Cameroon a study carried out indicated that retailers and wholesalers interviewed indicated that they wish the supply of the African walnut was more steady as there was a strong and ready market in the entire sub-region. A 15kg bucket of raw, unshelled nut costs anywhere from 7,000 to 12,000 FCFA (US$10-18) depending on season. Around harvest time, small lots of 8 – 10 boiled seeds are sold for 100 CFA (15 US cents) but when supply goes down, the same 100 CFA will get only 4 – 5 seeds. It is evident that the popularity of African walnut is increasing as market demand is increasing. The profits are improving the purchasing power of families, their living environment and the fight against rural poverty.

5.0 Conclusion

The need for Nigeria as a nation to improve its agricultural production and productivity has become imperative.

With the free descent in the global price of oil, the major foreign exchange earner in the country, the need to mobilise efforts to promote decrease in foreign exchange expenditure while increasing industrial utilisation of locally available raw materials is now a very important option for national industrial development. The first step is to exploit materials and techniques for grafting and seed germination in African walnut by farmers in the country. Through research and development improved varieties which have the qualities the market desire can be developed. Furthermore, modern propagation methods including tissue culture could allow the rapid multiplication of uniform seedlings for farmers to plant in their fields. In Cameroon, many rural resource centres where farmers receive training in agroforestry, nursery management, tree domestication, use of microfinance and community infrastructure improvement have increased annual incomes from the sale of improved indigenous trees ranging from $20,000 – 30,000 indicating that tree domestication is a powerful tool for poverty alleviation in rural areas. Closely allied with this is the need for value chain development which will allow farmers to reap livelihood benefits from cultivating the vine. This should be backed up with better processing and storage methods that will ensure steady supply of the nuts and their pricing. Thus, while African walnut has a variety of industrial uses as enumerated, a concerted effort that will involve that the government, research institutes and the private sector must be marshalled to make industrial application of the plant possible in the country. This will open the way to walnuts serving as a true cash crop that contributes to the wellbeing of households, communities and environment. It will also reduce the dependence on imported raw materials locally.

Table 1: Physicochemical Characteristics of Walnut Oil

Parameter	Composition
Oil yield (%)	57.50± 0.06
Moisture (%)	1.59 ± 0.04
Specific gravity (g cm^{-1})	0.91 ± 0.02
Saponification value (mg KOH g^{-1})	179.87 ± 0.3
Iodine value (gl $100g^{-1}$)	7.31 ± 0.02
Free fatty acid (%)	9.47 ± 0.1
Acid value (mg KOH g^{-1})	87.13 ± 0.05
Peroxide value (meqO_2 g^{-1})	9.67 ± 0.1
Ester value (mg KOH g^{-1})	89.74 ± 0.01
Refractive index	1.42 ± 0.03
Unsaponifiable matter (%)	12.26 ± 0.05
Biofuel potential (Hu) MJ L^{-1}	40.84 ± 0.01
Colour	Yellow

Isong *et al* (2013)

Table 2: Physico-chemical Properties of Walnut Seed Oil (WSO)

Properties	
Colour	Golden yellow
Acid value (mg KOH/g)	11.07
Saponification value (mg KOH/g)	203.45
Iodine value (g/100g)	153.05
Specific gravity (30ºC)	0.9320

Momodu *et al* (2011)

Table 3: Proximate Composition of African Walnut

Nutrients	% Wet Basis
Moisture	36.58
Protein	24.01
Oil	17.39
Fibre	5.99
Ash	2.89
Carbohydrate	13.14

Ihemeje *et al* (2012)

Table 4: Some Mineral Elements Contained in African Walnut

Nutrients	% Mg/100g
Calcium	45.01
Magnesium	60.20
Copper	2.05
Iron	2.91
Zinc	5.96
Potassium	23.14
Sodium	8.07

Ihemeje *et al* (2012)

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