Potential health and economic benefits of three locally grown nuts in Nigeria: implications for developing countries

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Abstract

Malnutrition and lack of economic sustainability are major problems in developing countries. This study was conducted to evaluate and compare the nutrients’ contents of three locally grown nuts in Nigeria (local groundnut, Kampala groundnut and breadnut) and highlight their health and economic potentials. Proximate analysis, chemical properties, minerals and fatty acids composition of the nuts were determined. The highest protein, crude fibre and carbohydrate contents were found in Kampala groundnut, local groundnut and breadnut respectively. Their sodium-potassium ratios were all less than 1.0 and their oils have mainly unsaturated fatty acids. Their acid values ranged between (2.41–6.34 mgKOH/g) while the iodine values were between 36.0 and 93.0 I\textsubscript{2} g/100 g. Analysis of the nuts and their oils indicated that they could help in solving malnutrition problem and also boost nations’ economy. Encouraging their large scale production can enhance adequate nutrition and sustain industrial growth in developing countries.

Keywords: Nutrition, Food analysis, Food science
1. Introduction

Malnutrition is a major public health issue in most parts of the developing world where it is linked to about 40–60% of under-five children deaths and many chronic adult diseases (UNICEF, 2013; Fetuga et al., 2011). It usually begins in the early childhood period in the form of inadequate nutrients intake as a result of improper feeding practices of young children by their parents and care givers (Semukasa and Kearney, 2014). Factors attributed to malnutrition in developing countries include: poverty, ignorance, lack of household food security and knowledge of use of locally available local food sources, and inappropriate complementary feeding diets (Semukasa and Kearney, 2014; Zakari et al., 2014; Frimpong, 2013; FAO, 2010). In recognition of the unpleasant effects of malnutrition, several international bodies like the United Nations International Children’s Emergency Fund (UNICEF), World Health Organisation (WHO), Food and Agricultural Organisation (FAO) and the World Bank have launched various programmes in attempts to solving the problems of inadequate nutrition in the developing countries (Frimpong, 2013; UNICEF, 2005). As laudable as these international supports are, they may not be sustainable if they are not adequately backed with local contents because they are largely foreign aid driven. Therefore, there is a need for local efforts by individual countries geared towards solving their problems of inadequate nutrition and economic viability through the use of indigenous, cheap and sustainable strategies. One of such approach will be to focus more research on locally available food sources with the aim of highlighting their potentials to solving the dual problems of malnutrition and economic sustainability as being done currently in some African countries (Bonsi et al., 2014; Niyibituronsa et al., 2014; Amagloh et al., 2012). In Nigeria, groundnut and breadnuts are plants products with suspected vast nutritional and economic potentials.

Groundnut (Arachis hypogaea) generally known as peanut is one of the most important foods because of its high concentration of oil, fat and protein. It is the 13th most important food and most important oil seed crop of the world (Anyasor et al., 2009). Groundnut is a specie in the legume family and it is one of the major sources of edible oil and food in Nigeria. There are two major species namely: Local groundnut (LG) and Kampala groundnut (KG) that are commonly grown and consumed in all parts of the country (Anyasor et al., 2009). They are important sources of vegetable oil and also serve as major sources of food diets to citizens of many countries where they readily give fatty acids, plant proteins and crude fibres when consumed (Anyasor et al., 2009). Fatty acids present in groundnut demonstrated beneficial effects on the cardiovascular system (Soumia et al., 2013). They also have anti inflammatory properties which are attributed mainly to their ability to modify prostaglandin and lipid synthesis. Dietary supplementation of very long chain monoenoic fatty acids such as erucic acid and nervonic acid derivable from groundnuts help in brain development and neuronal functioning of a
growing child and individuals with Zelweger syndrome, multiple sclerosis and adeno-leukodystrophy among other disease conditions (Anyasor et al., 2009). Groundnuts proteins are plant proteins which are cheaper and more readily accessible than animal proteins. This is more apt for inhabitants of the developing world where there is high rate of poverty and inequitable wealth distribution (World Databank, 2010).

Breadfruit (Artocarpus altilis) is a perennial plant that belongs to the mulberry family. Breadfruit seeds known as Breadnuts Artocarpus camansi constitute a very important diet in Nigeria (Soumia et al., 2013). Breadnut (BN) is a seeded breadfruit which is primarily grown for its nutritious seeds which vary in their seed number and sizes. The nuts are usually consumed when immature, thinly sliced and boiled as a vegetable in soups or stews and are regarded as the poor man’s substitute for yam because it is cheap and so, used in several traditional food preparations in lieu of yam. It is a good source of protein and low in fat content compared to other nuts such as almond and Brazil nut (Mayaki et al., 2003; Adeleke and Abiodun, 2010).

Despite the wide availability of breadnuts and groundnuts, only few studies have commented on their vast nutrition and economic values. While some studies have examined oils extracted from groundnut seed (Anyasor et al., 2009; Musa et al., 2012), some of its other important nutrients’ contents are yet to be studied. To the best of our knowledge, only very scanty work have been carried out on breadnuts (Adeleke and Abiodun, 2010). Given the wide presence and use of these plants’ products in Africa, it is important that their vast nutrients and economic potentials are brought to light. Therefore, the aims of this study were to examine and compare the nutrients’ and chemical contents of the nuts as well as the physicochemical properties of the oils extracted from them. It is envisaged that doing this will help to further unmask their nutrition, health and industrial application potentials that could be of immense benefits to developing countries given their wide spread availability in these countries.

2. Materials and methods

2.1. Collection of samples

The three species of nuts (LG, KG and BN) were collected from local farms in Ekiti State, Nigeria. The samples were identified at the plant science Department of the Ekiti State University. The seeds were removed and washed several times under running water to remove any stone and adhering materials. The samples were then washed several times with distilled water. Representative samples were taken for moisture content estimation and the remaining ones were air dried. The dried samples were then milled using electric grinder and stored in airtight polythene bags at a temperature of 25 °C prior to analysis.
2.2. Proximate analysis

Moisture content, crude fat, crude fibre, crude protein, ash and carbohydrate of the powdered samples were determined according to the methods of Association of Official Analytical Chemists (AOAC, 1995).

2.3. Extraction of oil

50 g of the powdered sample was placed in the thimble and about 150 ml of normal hexane was poured into the round bottom flask. The oil was extracted for 8 hrs at 60 °C using Soxhlet apparatus and was concentrated using a rotary evaporator (Rotavapor R110). The percentage oil yield was calculated thereafter (AOAC, 1995).

2.4. Physicochemical analysis

Physicochemical properties: acid value, saponification value, iodine value and refractive index of the extracted oil were carried out as described by AOAC (AOAC, 1995). The mineral compositions of the samples were determined using an Atomic Absorption spectrophotometer S series 711430V1.26 following the manufacturer’s specifications.

2.5. Determination of fatty acid profile

The fatty acid composition was determined according to Cocks and Van Rede (1966) with slight modification. 0.5 g of oil extracted was mixed with 3 ml of dimethylether and together with 0.2 ml of sodium methoxide to form a colloidal solution. The solution was allowed to settle, and centrifuged to precipitate into solid. The solid was filtered and the filtrate was kept for the gas chromatography analysis. 1 μl of the filtrate was injected into gas chromatography instrument (HP 6890 Powered with HP chemstation Rev. A 09.01 [1206] software) equipped with flame ionization detector. Conditions were as follows: stainless steel column 30 m X 0.25 mm X 0.25 μm packed with HPINNOWAX; column temperature was 250°C; carrier gas N₂, 35 ml/min; H₂, 30 ml/ min. Individual fatty acids were identified by comparing their retention times with a certified fatty acid methyl esters (FAME). The relative percentage of each fatty acid was quantified as percentage of the total fatty acids.

2.6. Statistical analysis

Statistical analysis was done using Chi – square test of independence with Microsoft word excel package and significance was established at P values less than 0.05.
3. Results

3.1. Comparative composition of local groundnut, Kampala groundnut and breadnut

The results of the proximate analysis (on dry basis) are presented in Table 1. BN had significantly higher moisture content (45.0%) when compared to LG or KG. Conversely, LG and KG have significantly higher amount of crude fibres (p = 0.04). Also, there were significant differences in the carbohydrate and crude protein contents in favour of Breadnut and Local groundnut respectively.

3.2. Fatty acid composition

As shown in Table 2, apart from oleic acid, the three samples are rich in essential fatty acids but breadnut significantly contains more essential fatty acids such as linoleic acid (43.6%) compared to 26% each for local groundnut and Kampala groundnut respectively. Also, Breadnut is significantly richer in linolenic acid content (12.4%), vs 0.08% each for local groundnut and Kampala groundnut respectively. Both the local groundnut and the Kampala groundnut have higher contents of arachidonic acid and behenic acid.

Table 3 shows the total fatty acids of the nuts and their energy level. BN have the highest amount of polyunsaturated fatty acid (PUFA) (56.0%) and also have the highest amount of saturated fatty acid (SFA) (28.71%) while KG has the highest amount of monounsaturated fatty acid (MUFA). All the three nuts have UFA/SFA ratios of greater than one.

### Table 1. The result of proximate analysis on dry basis.

|                        | Local groundnut (LG) | Kampala groundnut (KG) | Breadnut (BN) |
|------------------------|----------------------|------------------------|---------------|
| Moisture content (%)   | 19.5                 | 17.6                   | 45.0*         |
| Ash content (%)        | 3.50                 | 4.00                   | 2.00          |
| Crude fat (%)          | 38.2*                | 39.7*                  | 2.00          |
| Crude fibre (%)        | 9.63*                | 5.08*                  | 1.38          |
| Crude protein (%)      | 26.3*                | 21.2                   | 12.6          |
| Carbohydrate (%)       | 4.08                 | 12.4                   | 21.5*         |
| Energy level of fat(kJ/g) | 1413.4               | 1468.9                 | 595.7         |
| Energy level of protein (kJ/g) | 163.7               | 360.4                  | 273.7         |
| Energy level of carbohydrate (kJ/g) | 69.36              | 210.8                  | 214.2         |
| Total energy (kJ/g)    | 1646.46              | 2040.1                 | 1083.6        |

Energy level calculated using Atwater’s general factor of 37 kJ/g for fat, 17 kJ/g for protein and 17 kJ/g for carbohydrate (FAO, 1998). *Statistically significant at P < 0.05.
3.3. Mineral contents

As shown in Table 4, overall, the Kampala groundnut contains more minerals and there is a close similarity between its minerals content and that of Local groundnut. The Kampala groundnut has the highest amounts of potassium 23.6 g/100 g compared to Local groundnut (22.5 g/100 g) and Breadnut (5.85 g/100 g). Also it has the highest amount of calcium 75.5 g/100 g compared to Local groundnut (74.7 g/100 g) and Breadnut (0.03 g/100 g). The Na/K ratios for the three nuts were less than one and they all have equal iron contents. However, chromium and copper were not found in them while Fe and Mn were detected in very minute quantity 0.01 and <0.01 respectively in BN.

Table 2. Fatty acid composition of LG, KG and BN.

| Fatty acid composition | LG (%) | KG (%) | BN (%) |
|------------------------|--------|--------|--------|
| Myristic (C14:0)       | 0.15   | 0.16   | 0.00   |
| Palmitic (C16:0)       | 11.6   | 11.1   | 19.4   |
| Palmitoleic (C16:1)    | 0.39   | 0.41   | 0.54   |
| Stearic (C18:0)        | 4.40   | 4.48   | 9.29   |
| Oleic (C18:1)          | 51.2*  | 51.9*  | 14.7   |
| 8Linoleic (C18:2)      | 26.0   | 26.0   | 43.6*  |
| 8Linolenic (C18:3)     | 0.08   | 0.08   | 12.4   |
| 8Arachidic (C20:0)     | 2.15   | 2.07   | 0.01   |
| 8Behenic (C22:0)       | 4.01   | 3.76   | 0.01   |

LG – Local groundnut, KG – Kampala groundnut, BN – Breadnut.
* Significant at P < 0.05.
a Essential fatty acids.

Table 3. Total fatty acids and their energy levels.

|                  | LG (%) | KG (%) | BN (%) |
|------------------|--------|--------|--------|
| SFA (%)          | 22.31  | 21.57  | 28.71  |
| MUFA (%)         | 51.59* | 52.31* | 15.24  |
| PUFA (%)         | 26.08  | 26.08  | 56.0*  |
| UFA/SFA          | 3.48   | 3.63   | 2.48   |
| Energy level of SFA (kJ/g) | 8.25 | 7.98 | 10.62 |
| Energy level of MUFA (kJ/g)    | 19.08 | 19.35 | 5.64   |
| Energy level of PUFA (kJ/g)     | 9.65  | 9.65  | 20.72  |

Saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), unsaturated fatty acid (UFA), LG – Local groundnut, KG – Kampala groundnut, BN – Breadnut.
* Significant at P < 0.05.
3.4. Physicochemical parameters of the extracted oils from the nut

As shown in Table 5, the nuts have good oil yields and this was highest for local groundnut and least for breadnut and all the oils were liquid at room temperature. The oils acid values were 5.02, 6.34 and 2.41 mgKOH/g for LG, KG and BN respectively. The oils have iodine values of 93.0, 36.0 and 44.3 mg/KOH for LG, KG and BN respectively with LG having significantly higher value than others. All the oils had high saponification values and these were 168.3, 201.9 and 242.0 mgKOH/g for LG, KG and BN respectively with BN having a significantly higher value than the others.

Table 4. The result of the mineral analysis of LG, KG and BN.

| Metals | LG (g/100 g) | KG (g/100 g) | BN (g/100 g) |
|--------|--------------|--------------|--------------|
| Na     | 12.3\*       | 13.5\*       | 0.71         |
| K      | 22.5\*       | 23.6\*       | 5.85         |
| Ca     | 74.7\*       | 75.5\*       | 0.03         |
| Mg     | 0.22         | 0.54         | 0.03         |
| Zn     | 0.05         | 0.71         | 0.07         |
| Fe     | 0.01         | 0.01         | 0.01         |
| Cr     | ND           | ND           | ND           |
| Cu     | ND           | ND           | ND           |
| Mn     | 0.01         | 0.01         | <0.01        |
| P      | 0.46         | 1.20         | 0.46         |
| Na/K   | 0.55         | 0.57         | 0.12         |

ND: Not Detected, LG – Local groundnut, KG – Kampala groundnut, BN – Breadnut.
\* Statistically significant at \( P < 0.05 \).

Table 5. Physicochemical parameters of oils extracted from LG, KG and BN.

| PARAMETER                             | LG     | KG     | BN     |
|---------------------------------------|--------|--------|--------|
| State at room temperature             | Liquid | Liquid | Liquid |
| Oil yield (%)                         | 25.7   | 20.5   | 12.5   |
| pH                                    | 4.73   | 5.70   | 4.86   |
| Acid Value (mg KOH/g)                 | 5.02   | 6.34   | 2.41   |
| Kinematic Viscosity @ 40 °C           | 43.2   | 45.2   | 47.2   |
| Refractive index @ 40 °C              | 1.47   | 1.47   | 1.47   |
| Saponification Value (mgKOH/g oil)    | 168.3  | 201.9  | 242.0\*|
| Iodine Value (1g/100 g)               | 93.0\* | 36.0   | 44.4   |

LG – Local groundnut, KG – Kampala groundnut, BN – Breadnut.
\* Significant at \( P < 0.05 \).
3.5. Estimated nutrients' yields of the nuts relative to the recommended daily allowance

As shown in Table 6, daily consumption of 100 g each of LG, KG and BN will meet substantial portions of the RDA of these nutrients in both children and adults respectively.

4. Discussion

The high contents of fat, protein and carbohydrate in the evaluated nuts (Table 1) make them good sources of the bulk ingredients needed to prevent gross malnutrition in addition to preventing some macronutrients' and micronutrients' deficiencies. Hence, given their wide availability, it could be speculated that these food items could be used to alleviate the high burden of under nutrition and its associated sequelae among the inhabitants of most developing countries if they are cultivated and consumed on a large scale as they could help to ensure household food security in these countries (UNICEF, 2013; FAO, 2010; Kikafunda et al., 2014). According to the Food and Agricultural Organization (FAO), “households are food secure when they have year-round access to the amount and variety of safe foods their members need to lead active and healthy lives. At the household level, food security refers to the ability of the household to secure, either from its own production or through purchases, adequate food for meeting the dietary needs of all members of the household” (FAO, 2010). The indicators for measuring food security include: universality/availability, accessibility, adequacy, safety and dietary contents of foods sources (Semukasa and Kearney, 2014; Frimpong, 2013). All the nuts met these criteria and of particular note is the observation that breadnut is a perennial plant and as such, has the tendency to be available all year round for human uses in order to achieve household food security.

Fat is important for several functions in humans, some of which include: supply of calories, digestion and absorption of nutrients (especially fat soluble vitamins), protection and cushion for vital organs in human body, insulation from heat loss and temperature regulation. The high crude fat contents of the nuts points to their ability to fulfil these roles when consumed by an individual. It also indicates their potential to be sources of plant oils which are more health friendly compared to animal fats as plant oils contain less cholesterol and they do not predisposed to medical conditions such as atherosclerosis and heart diseases (Anyasor et al., 2009). The two species of groundnut evaluated had significantly higher percentage of crude fat and this may explain why groundnut is one of the major sources of vegetable oil in Nigeria. In addition, the results of the energy level of the samples (Table 1) showed that all the three samples when adequately consumed can supply the body with good amount of energy needed for day-to-day activities. These observations further highlight the suitability of the nuts as key components of daily
Table 6. Estimated nutrients’ yields of the nuts relative to recommended daily allowance. Source: Dietary reference intake reports available at www.nap.edu.

| Nutrient       | Consumption of 100 g of nut per day | Estimated net nutrient yield                      | Recommended daily allowance (RDA) a               |
|----------------|-------------------------------------|---------------------------------------------------|--------------------------------------------------|
| Protein        | Local groundnut                     | 0.2–0.8 g/Kg body weight in children/day          | 1–3 g/Kg body weight in children/day             |
|                |                                     | 11.6–20 g/day in adults                           | 34–56 g/day or 0.8/Kg body weight in adults/day  |
|                | Kampala groundnut                   | 0.1–0.5 g/Kg body weight in children/day          | As above                                         |
|                |                                     | 9–16 g/day in adults                              |                                                  |
|                | Breadnut                            | 0.2–0.5 g/Kg body weight in children              | As above                                         |
|                |                                     | 4.8–9.2 g/day in Adults                           |                                                  |
| Fat            | Local groundnut                     | 25 g/day                                          | 30 g/day for young children aged ≤1year           |
|                |                                     |                                                  | Undetermined and variable for older children and other age groups |
|                | Kampala groundnut                   | 25 g/day                                          | As above                                         |
|                | Breadnut                            | 13 g/day                                          | As above                                         |
| Carbohydrate   | Local groundnut                     | 3.3 g/day                                         | ≈100 g for children                              |
|                |                                     |                                                  | 130 g for adults                                 |
|                | Kampala groundnut                   | 9.9 g/day                                         | As above                                         |
|                | Breadnut                            | 17.5 g/day                                        | As above                                         |

a RDA.
diets for both adults and children. A more practical application will be to encourage their more use in diets for growing children who are often in the need of calorie-dense diets given their high-energy requirements (Needlman, 2004).

The nutrient content reported for these nuts are in agreement with the reports of other authors who had worked on these nuts (Shahzad et al., 2011; Malomo et al., 2011). As shown in Table 2, the high contents of essential fatty acids in the nuts lend credence to previous reports by authors (Shahzad et al., 2011; Anyasor et al., 2009; Mayaki et al., 2003), that these nuts are rich in this nutrient. These findings highlight their importance for healthy living, normal growth and development. Ironically, the early childhood period correspond to the period of rapid brain growth and development needing the essential fatty acids present in the nuts (Needlman, 2004). It is also a period characterised by feeding challenges for a child in the developing countries especially when they are transiting from breast milk to semi-solid diets because, readymade nutritious substitutes are often unavailable or too expensive and most caregivers have been shown to lack the knowledge of using locally available substitutes (Semukasa and Kearney, 2014; Amagloh et al., 2012). Taking together, these perhaps, explain why groundnuts are readily recommended as parts of the food ingredients usually added to cereals to make them more suitable for complementary diets in children (Bonsi et al., 2014; Gupte, 2001). Apart from supplying the fatty acids and good calories (Table 3), they also give the complementary diets the needed flavour to make the food palatable to infants who are usually very choosy in their early phase of taking other food items aside breast milk thus emphasizing the relevance of these nuts (Bonsi et al., 2014; Gupte, 2001).

Furthermore, BN is very rich in polyunsaturated fatty acids (PUFA) and, the human brain needs a high level of PUFA (Needlman, 2004) and high consumption of PUFA is not only associated with a lower incidence of depression, but also a lower risk of Alzheimer’s disease and decreased prevalence of age – related memory loss. In Nigeria, Breadnut is being called the poor man’s food because of its perennial availability and it is readily used as a substitute for yam which is more costly and seasonal compared to breadnut that is available all through the seasons (Adeleke and Abiodun, 2010). Hence, wide scale cultivation of breadnut plant could assist in not only bridging the nutrition gaps but also help in economic sustainability for developing nations. The high ratio of UFA/SFA of all the nuts also gives them good nutritional quality as it has been found that, a UFA/SFA ratio greater than one for any foodstuff as found in these nuts, signifies improved nutritional benefits of such food (Bonvehi and Jorda, 1997).

The results of the mineral analysis as shown in Table 4, indicates that, the nuts are rich in potassium and calcium among other minerals. Potassium is an important intracellular constituent in the body that is needed for the regulation of many body
processes and the Recommended Dietary Allowance (RDA) for potassium is an average of 3.8 g/d for children and 4.7 g/d for adults (DRI, 2011). Therefore, the samples can be good sources of potassium for both adults and children.

Furthermore, the sodium-potassium (Na/K) ratios of all the nuts were less than one and they are natural sources of these minerals (Table 4). Hence, these minerals as present in the nuts are better than artificial sources. The ratio of sodium to potassium in foods consumed by an individual is of great importance for the prevention of heart diseases and high blood pressure (Mozaffarian et al., 2014). To this end, diets which are natural and have high potassium content relative to sodium (sodium-potassium ratio less than one) are more health-friendly and are often recommended by medical experts to prevent cardiovascular related diseases (Mozaffarian et al., 2014). Nothing drives home the need for the consumption of cardiovascular disease prevention diets than the high morbidities and mortalities associated with cardiovascular diseases in low and middle income countries where 80% of the 1.65 million global annual deaths from these diseases occur (Mozaffarian et al., 2014). Excessive intakes of salts and substances with increased Na/K ratios have been linked with cardiovascular related disease conditions and many other health problems (Graudal et al., 2012; Yang et al., 2011). Interestingly, consumption of nuts has been recommended as natural food sources alongside vegetables and avocados to combat the scourge of these health conditions (Mozaffarian et al., 2014; Yang et al., 2011). Therefore, the need for the regular consumption of the evaluated nuts in order to combat the scourge of cardiovascular and other related diseases is recommended. To the best of our knowledge, our findings of health friendly Na/K ratios in these nuts is the first of such report and this further justifies the place of these nuts as a remedy to preventing some health problems in humans if they are grown and consumed by individuals in lieu of artificial sources of nuts. This is more apt given the lack of both infrastructure and financial wherewithal in most developing countries to tackle the scourge of most diseases.

The groundnut species had significantly high calcium values and calcium plays a fundamental role in the constitution of biological systems. Its presence in bone provides an individual with the required rigidity and support (Gupte, 2001). Thus, regular intake of the groundnuts can supply adequate calcium that the body needs for various metabolic processes and bone development. This is especially so for children and elderly who are in constant need of these minerals for their well-being (Needlman, 2004; Gupte, 2001). That Chromium (Cr), a heavy metal, was not detected in the nuts indicate they are safe for human consumption and free from the harmful health effects of this metal when taken in excess.

Apart from the minerals contents values of the nuts, they also serve as potential sources of good yields of dietary protein, carbohydrate and fat. For example, as
shown in Table 6, daily consumption of 100 g each of LG, KG and BN will meet substantial portions of the RDA of these nutrients in both children and adults respectively (Needlman, 2004; Gupte, 2001; DRI, 2011). These observations further justify the high nutritional and health values of these nuts.

Also, the groundnuts have good oil yield and the oils are liquid at room temperature indicating their likelihood of having high percentage of saturated fatty acid and thus will not be able to congege and block blood vessels when consumed by humans thereby preventing the potential to obstruct blood flow and cause health problems for individuals consuming them. In addition, the refractive index of the oils is approximately 1.47 for all the samples studied which is similar to that of castor oil (1.47) and pumpkin (1.46) (Ukpan et al., 2006; Alfawaz, 2004). This indicates their safety and usefulness for household purposes.

Furthermore, the acid values of the nuts are 5.02, 6.34 and 2.41 mgKOH/g for LG, KG and BN respectively. These values are greater than the 0.82 mgKOH/g obtained for cashew nut seed oil as reported by Aremu et al. (2005) but falls within the recommended codex value of 6.6mgKOH/g for virgin oils further re-affirming that LG, KG and BN seed oils can be classified as edible oil (FAO, 1999). Also, the oils from the nuts have high saponification values and given that, there is an inverse relationship between saponification value and the weight of fatty acid in plant oils, it could therefore be inferred that the oils from these nuts contain greater number of fatty acids of low molecular weights that can have good application in the soap industry. In addition, the iodine values of the oils qualify them to be classified as non drying oil because all of them have values that are less than 100. This underscores their great applicability for domestic and industrial cooking purposes as the oil will not readily dry up when being used for cooking. This gives oils from these nuts comparative advantage over other vegetable oils and could thus help their users to save cost and improve their economic status. In general, results of LG and KG are similar and this confirmed them as varieties of the same species. The values obtained for the physicochemical properties of these oils (Table 5), are in agreement with the report of other authors (Musa et al., 2012; Bwai et al., 2013).

5. Conclusion

This study highlights the health, domestic and industrial potentials of the three nuts. Apart from having good contents of carbohydrate, fat, protein and minerals, their oils exhibited good physicochemical properties and are rich in essential fatty acids. This makes them of good health benefits as well as having the potential to providing industrial application especially within the soap and food industries. The low iodine values of their oils qualify them as non-drying oil and this gives them comparative advantage over other vegetable oils when used for domestic cooking.
purposes. These attributes, make the nuts to be of good value in alleviating and combating the scourge of under nutrition and enhancing industrial growth in the developing countries if they are widely accepted and cultivated. In addition, the Breadnut has an added advantage of being available for human use all through the seasons because it is a perennial crop and so, its availability can be guaranteed and thus helping to ensure household food security. Therefore, encouraging large scale production of these nuts can be used to enhance adequate nutrition and sustain industrial growth in developing countries.

Declarations

Author contribution statement

Ayomadewa M. Olatunya: Performed the experiments; Wrote the paper.

Oladele S. Olatunya: Analyzed and interpreted the data; Wrote the paper.

Emmanuel T. Akintayo: Conceived and designed the experiments.

Competing interest statement

The authors declare no conflict of interest.

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