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Evaluation of the physicochemical properties and fatty acid profiles of groundnut oil (*Arachis hypogea* L) in Southwestern Nigeria

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Abstract
Fresh groundnut seeds were purchased at starlight market, Sabo along Ogbomoso-Ilorin road, Ogbomoso. The oil was extracted by pressing method and analyzed for proximate, vitamin, physicochemical and fatty acids compositions using standard methods of analysis.
The proximate analysis result revealed that crude fat was in abundance (98 ±0.12 %) while other nutrients were present in traces. Vitamin E was the highest vitamin followed by Thiamine (B_1) and riboflavin (B_2) with the following concentrations: 21.28±0.012 mg/100g, 17.16±0.008 mg/100g and 16.56±0.002 mg/100g respectively. The physicochemical analysis revealed that saponification value was higher (142.4 ± 0.02 mgKOH/g) although below permissible level for vegetable oil followed by the iodine value (42.61±0.12 g/100g) and acid value (3.25 ±0.05 mgKOH/g) while peroxide value was 0.302± 0.02 meq/1000g.
The major fatty acids present were cis-9-hexadecenal (62.70%), 15-hydroxypentadecanoic acid (17.2%) and 9-octadecynoic acid (10.5%), while others were in traces.
The study has shown that the oil contained nutrients that make up balance diet and the vitamin E, B_1 and B_2 could make the oil a remedy for infertility and support body metabolism, therefore, the oil could be harmonized as food supplement, industrial raw material and medicine.

Keywords: Arachis hypogeal, proximate, vitamins, physicochemical, vegetable oil

Introduction

Fats or oils consist of a wide group of compounds that are soluble in organic solvents and insoluble in water. They have lower densities than water and at normal room temperature range inconsistently from liquids to solids depending on their structure and composition. The words oils, fats, and lipids are all used to refer to fat; oils are usually used to refer to fats that are liquids at room temperature, while fats are usually used to refer to fat that are solid at normal temperature. Lipids are used to refer to both liquids and solids fats (Anthen *et al*., 1993) [4]. In quality control of edible oils, several parameters such as iodine value (degree of unsaturation), saponification value (average molecular weight), moisture content, and peroxide value as well as the acid value content are of interest as they determine the quality and hence the economic value of the product (Mendil *et al*., 2009) [24]. Several factors affect the edible oil quality such as harvesting and carriage systems, method and duration of storage, and processing technology. The major factors affecting edible oil quality are temperature, moisture, sunlight, soil fertility, and nutrients. It is possible to determine by different analytical techniques how to assess the quality of edible oil and to avoid possible adulterations (Manorama and Rukmini, 1991) [22]. *Arachis hypogaea* L (ground nut or peanut) belongs to the family of *Fabaceae*. It is the sixth most important oil seed crop in the world and found in the tropical and temperate zones (FAO/WHO, 1993) [14].

Arachis hypogeal were used in the form of various food items such as roasted, ground, oil, boiled or raw but the most commonly utilized form is the roasted (Rubico *et al*., 1987) [31]. In most countries *A. hypogea* seeds are mainly used as snacks, food supplement and their oil are used for cooking and its other remnants used as feed for animal husbandry (Jambunathan, 1991) [19]. Edible oils from plant origins are good because of the presence of polyunsaturated fatty acids present in them such as linoleic and linolenic acids. These fatty acids have important biological functions, structural and functional roles and they could serve as sources of energy. The linoleic acid is the most abundant fatty acid in nature, and it is the precursor of other omega-6 fatty acids. The omega-3 fatty acids are synthesized from α-linolenic acid. The human body cannot synthesize fatty acids with odd number of carbon atoms chain; however, there were studies in which this type of fatty acids was identified in a low concentration in plasma. Once ingested, short chain PUFAs are converted to long-chain fatty acids. These are critical for mammalian cells in order to perform various biological functions, such as sustaining the structural integrity of cellular membranes and serving as signaling molecules. They are highly enriched in the adipose tissues, for example in the brain, where they participate in the development and maintenance of the central nervous system during both embryonic and adult stages. Vegetable oil had made several contribution to the diet in many homes in the whole world where it serves as a source of protein, vitamins, lipids and fatty acids for human nutrition which include repair of worn out tissues and new cells formation (Gaydon *et al*., 1983; Grosso *et al*., 1997) [15, 16]. Literature survey has shown that many researches had been conducted on the *A. hypogaea* seed of different varieties from different sources to ascertain their nutritional compositions but the oil has been analyzed for physicochemical compositions and fatty acids compositions without considering the oil as a factor in food supplement or raw materials in the formulation of drugs. Therefore, the objective of this research is to analyze the oil in line with the nutritional and chemical compositions the oil possesses which can be harmonized for the formulation of food supplement and treatment of ailment due to deficient of vitamin E or B_1 and B_2.

Material and Methods

Sample Collection

Fresh raw *Arachi hypogaea* seeds were purchased at Starlight junction, Sabo market along Ogbomoso-Ilorin road, Ogbomoso North Local Government Area, Oyo State, Nigeria. The seeds were packed in polyethene bags and stored under room temperature in the laboratory until they were required for analysis.

Sample Preparation

The fresh raw *Arachi hypogaea* seeds were rinsed with water and exposed to air under room temperature in the laboratory for three days in a stainless bowl. Sandy soil was gathered from a mountain top at Oriapata, stadium area, Ogbomoso, washed and heated in an oven at 105ºC until all the moisture evaporated and the sandy soil was dried, removed and cooled. The sandy soil that will be enough for the roasting of the *Arachi hypogaea* seeds was weighed and introduced into a frying pan spread within the pan placed on a gas cooker and the fresh raw seeds, 500 g was added into the pan that contained the dried sandy soil. The seeds were roasted for 30 min. stirring intermittently until desirable end products were obtained. The products obtained was allowed to cool and peeled. The obtained roasted peeled *A. hypogaea* seeds were ground using a grinding machine to obtain a paste which was pressed (cold compressed method) to obtained oil and the oil was collected into a container, corked and labeled kept prior to analysis.

Proximate analysis

Moisture content was determined by weighing 5 g of the oil sample which was introduced into a silica dish which has been previously dried and weighed. The oil was placed in the oven when the temperature of the oven was 105^0C and was dried for 3 h, cooled in a desiccator and weighed. The drying and weighing continues until a constant weight was achieved. Ash content was determined by ignition at 550^0C in a muffle furnace for 4 h (or until whitish-grey ash was obtained), protein by the Kjeldahl method, crude fibre by the acid and alkaline digestive methods all described by AOAC (1990) [5]. The carbohydrate content was estimated by difference, this was done by subtracting the sum of percentages of moisture content, crude protein, crude fat, crude fibre and ash from one hundred (Ayo and Agu, 2012) [9]. The energy values were estimated by multiplying the crude protein by 2, crude fat by 9 and carbohydrate by 4 (Asibey-Berko and Taiye, 1999) [7].

Vitamin analysis

The determination of thiamine and riboflavin (vitamins B1 and B2) were carried out using the method of Paul and Shaha (2004) [28] where high performance liquid chromatography (HPLC) analysis was conducted on the oil sample, vitamin C was done using DCPIP method as described by Smirnoff (2000) [34] while vitamin E was chromatographically determined using the standard method of Sanchez-Machado *et al*., 2010 [33].

Physicochemical analysis

Acid value was determined as described by ISI handbook, (1984). Peroxide value (PV) was determined using the method described by AOAC (1990) [5]. 5 g of the oil was dissolved in 30 ml of glacial acetic acid: chloroform (3:2, v/v). 0.5 ml of saturated potassium iodide (KI) was added and iodine (I_2) was liberated by the reaction with the peroxide. The solution was then titrated with standardized sodium thiosulphate ($Na_2 S_2 O_3$) using starch indicator. The iodine value (IV) was also determined by weighing 0.1 M iodine monochloride in acetic acid was added to 0.2 g of the oil dissolved in cyclohexane. The mixture was allowed to stand for 10 min, to allow for halogenation. 0.1 M of KI solution was added to reduce excess iodine monochloride to free iodine. The liberated iodine was titrated with a standardized solution of 0.1 M sodium thiosulphate using starch indicator. The iodine was then calculated (Nkafamiya *et al*., 2007) [25]. Saponification value (SV) was determined by adding 2 g of the oil sample was added to excess alcoholic KOH in a test tube. The solution was heated for 2 min to saponify the oil. The unreacted KOH was back - titrated with standardized 0.1 M HCl using phenolphthalein indicator. The SV was then calculated (AOCS, 1973; Nkafamiya *et al*., 2007) [25].

Fatty acid determination using gas chromatography

Gas chromatography (GC)

Gas chromatography was used in which non-volatile fatty acids were chemically converted to the corresponding

volatile methyl esters. The resulting volatile mixture was analyzed by gas chromatography. The oil was subjected to GC analyses on GC 2010 instrument. Column oven temperature 60 ºC injection temperature of 250ºCplit injection mode, at 100, 2k Pa; Column flow of 1.61 ml/min and total flow of 6.2 ml/min; 1.0 split ratio; oven temperature programming is 60ºC for 5 min and at the rate of 5ºC / min till 140ºC, 15 º/min till 280ºC.

Gas chromatography- Mass spectrometry

The GC-MS analyses were performed on GC-MS QP2010 Plus ion, Source temperature 200ºC; interface temperature 250ºC; solvent cut time 2.5 min; with relative detector gain mode and threshold 3000; scan MS ACQ mode; detector FTD; mass range of m/z 40-400.

Identification of components

Identification of the oil components were based on their retention indices (determined with a reference to a homologous series of n-alkanes), along with comparison of their mass spectral fragmentation patterns in computer matching against in built data and commercials such as Joulain and Koenia (1998) [20], Adams (1995) [1] and Massada (1976) [23] Libraries as well as in-house "Baser Library of Essential oil constituents" built up by genuine compounds and components of known oils.

Table 1: The proximate composition of *Arachi hypogaea* oil

Parameter	Composition (%)
Moisture content	1.00±0.001
Ash content	0.12±0.002
Crude protein	0.55±0.005
Crude fat	98±0.12
Crude fibre	0.25±0.05
Carbohydrate	0.08±0.002
Energy kcal/100g	883.42 ±1.098

Values are means (±SD) of triplicate determinations

Table 2: Vitamin composition of *Arachi hypogaea* oil

Vitamin	Composition (mg/100g)
Thiamine (B_1)	17.16±0.008
Riboflavin(B_2)	16.56±0.002
Ascorbic acid (C)	0.02±0.001
Tocopherol (E)	21.28±0.012

Values are means (±SD) of triplicate determinations

Table 3: Physicochemical Composition of the *Arachi hypogaea* oil

Parameter	Composition	FAO/WHO permissible level
Acid value(mgKOH/g oil)	3.25±0.05	0.6 mgKOH/g
Peroxide value (Meq/1000g KOH)	0.302±0.02	≤10 Meq/1000g
Iodine value (Wij's or g/100g)	42.61±0.12	50-55 g/100g
Saponification value (mg KOH/g oil)	142.4±0.08	190-209 mgKOH/ g

Values are means (±SD) of triplicate determinations

Table 4: Fatty acids Composition of the *Arachi hypogaea* oil

Fatty acid	Concentration (%)
Cis-9-hexadecenal	62.7
15-hydroxypentadecanoic acid	17.2
9-octadecynoic acid	10.5
9-octadecenoic acid	05.7
2-dodecenoic acid	03.9
Total	100

Values are means (±SD) of triplicate determinations

Results and Discussion

The result of the proximate analysis (Table 1) shows that the sample had a moisture content of 1.00±0.001% indicating that the sample is safe for storage since spoilage is always caused by the presence of moisture in a substance which encourages the growth of microorganisms. The ash content (0.12± 0.002%) signifies that the inorganic materials present in the sample were in minute quantity. Crude fat content was in abundance (98±0.12%) while crude protein followed (0.55%) and other nutrients were in traces. However, considering the usefulness of fat in human body in the absorption of fat soluble vitamins such as; vitamin A, D, E and K. Fat is also useful for energy manufacturing in the human system. Protein is also useful for the repair of worn out tissues, production of new tissues and aiding of growth in human system and this is an indication that the oil could be said to be a diet. The most abundant vitamin (Table 2) in the oil was vitamin E (21.28 mg/100g) followed by thiamine (vitamin B_1) and riboflavin (vitamin B_2). Vitamin E is antioxidants which protect the body tissues from damage caused by free radicals. It is also used in medicine to treat infertility and aging. Vitamins B_1 and B_2 have metabolic properties which help the brain to work effectively and also help the body cells to change excess carbohydrate, protein and fats into energy or glucose. Thiamine is important for nerve function while riboflavin is also important for skin health and normal vision. However, vitamin C which was in minute amount in the oil is used in prevention and treatment of scurvy; it is an antioxidant and a portion of an enzyme that is required for protein metabolism. It also helps with iron absorption and is important for the health of the immune system (WebMD Medical Reference, 2018).

The result shows that the acid value of *Arachi hypogaea* oil was above the permissible limit. Although the value was close to the reported value by Pearson, (1981) [29] which is 4.0 mg KOH/g for *Arachi hypogaea* oil while the value was above the reported value for oil from roasted *Arachi hypogaea* by Ayoola and Adeyeye (2010) [10] which is 2.5 mg KOH/g. Acid value determination is often used as a general indication of the condition and edibility of oil. The permissible level of acid value for all edible oils should be below 0.6 mg KOH/g (FAO/WHO, 1993) [14]. The saponification value (142.4±0.02 mgKOH/g) of the oil is low when compared to the standard (190-209 mg KOH/g) this low value shows that the lauric acid contents of the oil is also low and this is an important determinant of the suitability of the oil in soap making (Asuquo *et al*., 2010). However, the saponification value is quite closer to that of African pear oil (143.76 mg KOH/g) which could be good for soap making (Ikhuoria *et al*., 2007) [18]. This indicates that the oil could also be used in soap making since the saponification value is closer to that of the Africa pear oil. In this study, the iodine value of the oil was 42.61g/ 100g which is lower to the previous value (51.52g/ 100g) reported by (Eddy *et al*., 2011)

[13]. According to Codex Alimentarius Commission (1982) [12], a good drying oil should have an iodine value of 180 and above. The value obtained from this oil classifies it as non-drying oil since it is below 180 thus it cannot be used in the preparation of alkyl resins (Yahaya *et al.,* 2004) [35]. The low iodine values of the oil also reduce the risk of oxidative rancidity. Iodine value is used to determine the degree of unsaponifiable matter of fats and oils and it has been reported that lowering the iodine value improves the stability of the oil. The iodine value obtained in the analyzed oil sample was close to the standard iodine value (50–55g/100g) for *Arachi hypogaea* oil (FAO/WHO, 1993) [14]. Oils having high iodine values are polyunsaturated, indicating the degree of unsaturation and are desired by oil processors, while a lower iodine value is indicative of lower quality (Bello, 2011) [11], and lipid oxidation which might be due to metallic ions present among other factors, which enhances or promotes oxidation after the formation of hydroperoxide (Rossel, 1984) [30]. Peroxide value is used as indicators for deterioration of oil. It serves as an index of rancidity, thus high peroxide content of oil indicates a poor resistance of the oil to peroxidation during storage. The peroxide content obtained from this oil was 0.302 Meq/100g. This value, however was lower to the value (0.77mEqkg-1) earlier reported for *Telfairia occidentalis* by Yusuf *et al*, (2006) [36] and higher than the peroxide values for *Cocos nucifera* (0.21meq kg-1) reported by Obasi *et al.,* (2012) [26]. The peroxide value of the oil sample was less than the standard peroxide values (≤10 meq/1000 g) for vegetable oils deterioration. The low peroxide value indicates that the oil can resist lipolytic hydrolysis and oxidative deterioration when stored (Akanni, 2005) [2]. This standard value is for fresh oils while values in the range of 20-40 mEq/1000g results in rancid taste which indicate spoilage (Akubugwo *et al*., 2008) [3].

The peroxide value of the analyzed edible oil sample was in good agreement with the FAO/WHO recommendation standards. This indicates that there was no long time storage and no evidence of rancidity was observed in the edible oil sample. In general, storage time, atmospheric oxygen and light are factors that could lead to increase of peroxide value (Othman and Ngassapa, 2010) [27]. In Table 4 the most abundant fatty acid present was cis-9-hexadecenal (62.7%) followed by 15-hydroxypentadecanoic acid (17.2%) and 9-octadecynoic acid (10.5%). Fatty acids have important biological functions, structural and functional roles, and they represent an important source of energy. Most of these fatty acids are polyunsaturated fatty acids such as linoleic and linolenic acids which are referred to as Omega and they are useful for the prevention and treatment of cardiovascular diseases. Most are also used commercially in the preparation of lotions, cosmetics and pharmaceutical solvents.

Conclusions

This study shows that the *Arachi hypogaea* L oil could be a good source of protein, vitamins, (especially, E, B_1 and B_2) and polyunsaturated fatty acids which account for the nutritional value that can be accredited to the oil, therefore, the oil could be used as food supplement, pharmaceutical and dairy products. The physicochemical parameters showed that the oil was non-drying, stable and durable.

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