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Comparative Studies on the Physicochemical Properties and Elemental Composition of Oil Obtained from Three Species of Groundnut *Arachis hypogae L*

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Abstract: Comparative analysis as well as the elemental composition were carried out on oil samples obtained from three groundnut species namely; Earthnut, pygmy and pignut. .The extraction process was carriedout using soxhlet apparatus with hexane as the extraction solvent. The physicochemical characterization was carried out using standard methods in terms of Iodine value (IV), Free Fatty Acids (FFA), Saponification value and Acid Value (AV).The selected element of Na, Mg. Zn. Fe. Ca. K and p were determined by the use of atomic absorption spectrophotometer model buck VGP connected to a computer. The phosphorus content was determined using the calorimetric method. Proximate Analysis was also carriedout on the three species of ground. From the results of the analysis, Earthnut has 43.7% oil, Pygmy 45.8% and pignut 45.8%.The result of the physicochemical characterization of the oil sample showed that for earthnut the values of 43.72±0.21 IV. 3.01±0.12 FFA, 187±0.61 SV and an acid value of 6.86±0.15.Piygmt on the other hand has an iodine value (IV) of 84.59±0.20, 2.26±0.1 FFA, 185.13±1.25 SV and acid value of 3.01±0.12.Pignut oil was also characterized as having 88.82±0.26 IV. 1.32±0.06 FFA; 201.4±0.45 SV; and 2.44±0.15 acid value. For the elemental composition, Earthnut showed the values of 4.02±0.71 Na, 60.7±0.5 K, 3.98±0.04Mg, 2.28±0.62 Ca, 6.97±0.62 Fe, 3.20±0.11 Zn and 10.55±0.68 for Pgymy nut on the other hand showed values of 41.21±0.4 Na, 6.2±0.5 K, 4.38±0.8, 4.48±0.2 Ca, 6.85±0.41, 3.00±0.5, 11.2±0.2 P. Pignut however, showed values of 40.21±0.6 Na, 63.1±0.7 K, 5.61±0.5 Mg, 3.32±0.8 Ca, 4.67±0.7 Fe, 2,89±0.22 Zn and 10.3±0.24 P. Proximate composition also showed the following result for crude fibre, carbohydrates, fat and ash content as follows; Earthnut showed 3.7±0.3, 1.81±0.04,47.00±0.03, and 3.8±0.06 for the respective proximate parameters. Pgymynut also showed the following proximate values as follows; 3.7±0.3, 1.81±0.02 and 3.98±0.43 respectively. Finally, pignut on the other hand showed proximate results of 3.00±0.4, 1.3±0.3, 44.21±0.4 and 3, 36±0.6.The result of these investigations revealed that all the samples of groundnuts species analyzed for their oil quality are suitable for edible oil production as well as for industrial purposes. This implies that the oil samples under investigation can be commercially harnessed as source of nutrition as well as for industrial and pharmaceutical purposes.

Keywords: Proximate Analysis, Physicochemical Properties, Elemental Composition, Atomic Absorption Spectrophotometer, Free Fatty Acids (FFA) and Groundnut.

INTRODUCTION

Due to the ever demanding quest of Man to open up frontiers for new and improve sources of raw materials .There has been a corresponding increase in the demand for raw material by the various shops in the manufacturing. This has been further propelled by the corresponding paradigm shift to environmentally friendly and locally sourced raw material for sustainability and economic issues. This therefore left us with no options but to look inward and turn on the ingenuity in us to the realization of the goals set out to address sustainability as well as economic issue.

In with this research community the world over have keyed into this idea of looking inward and been creative and many countries of the the world are now engaged in productive research in to commercial crops for nutrition as well as industrial and commercial purposes.

As part of these efforts the world over, several studies were carried out with a view to value addition to peanuts and peanut related products. These efforts included the studies of the functional and chemical properties of kernals and defatted groundnut cake [1-4]: The result of the studies revealed that these nuts present a good source of proteins and lipids as well as defatted cake which could be used as animal food supplements as well as confectionary applications.

The viability of any industry is the ability of the industry to procure continuously raw materials and other industry inputs with little impediments and its ability to research on ways of replacing the sourced raw materials alternatively in the event of shortages or prompt availability of the desired raw materials. In line with the above, groundnut (Areceas Hypogeal l) in three respective species are annually grown crops and there should be looked at with the desired seriousness if industrialization is to taken seriously.

Groundnut is a herbaceous plant which consist of a variety that grows up to 30-46cm for some species of the American Origin and that of shorter African species that are 30-60cm long as in the studies conducted by [5].As pointed out by [4], the crop can be grown worldwide in the tropics and in temperate zones primarily as an oil source.

To add value to oil extracted from various species of the oil, the oil is characterized based on its physiochemical, proximate analysis to mention but a few. These studies are carried out in other to ascertain and discriminate between the various sources of oil for quality assurance. Some of these studies included fatty acid analysis by [4, 6 7]. The researches revealed the linoleic and other unsaturated content in high amounts. Deductions from these studies have shown that apart from the use of oils as edible sources, they can also be used industrially as additives in foods as well as in the cosmetic and source of polyols for the foam making industries.

Narrowing down to the Nigerian perspective, history has shown that before now, the groundnut were used mainly for exports to grow economies elsewhere and in return that generated foreign exchange as it is the main stay and contribution of the northern part of the country to the federal account and a stabilizer in terms of multiplier effects by providing immediate jobs to teaming youth population and boosting the purchasing power of our locals. That history has been now changed as the need to add value ourselves through the transfer of technology. This initiative led to springing up of many oil extraction industries and an upshot in the production of groundnuts.

In view of the reasons above, we ventured to extract oil from three species of groundnut grown mostly in all parts of Northern Nigerian with specific objectives of characterization of the extracted oils sample in terms of physiochemical and elemental composition for the comparative studies of the three species and the proximate studies of the de -oiled cake of the species of groundnut under investigation for comparative studies.

At the end of these we envisaged reproducible and dependable results that could furnishes those aspiration to became full time nut farmers as well as those nursing the ambition of setting up medium to small scale industries with some level of some dependable information.

METHODOLOGY

Sample and Sample Collection

Three groundnut samples oil samples were collected from various locations within Adamawa State that Madagali, Mubi Mubi North,and Michika local governments of Adamawa State, Nigeria.

Extraction of Oil

The methods described by [8] were adopted with slight modification for the extraction of the oil. Acetone was used as the extraction solvent.

Sample Preparation

The seeds were mechanically crushed into fine powder, cleaned and stored in a dry container until needed for further analysis.

Elemental Composition

The atomic absorption spectrophotometry model Buck VGP with computer readout was used for the analysis of Na, Mg, Zn, Fe, Ca, and K.

For Phosphorus determination the Vandate colorimeter method as modified was used. The yellow color test involving phosphomolyddate was used as a base for the determination of the phosphorus content of the oil.

With a view to determine the quality and consequently, the potential industrial applications of the samples used in line with this study, physical and chemical analysis were carried out based on procedures described by standard methods as follows:

Chemical Analysis of Oil

Iodine value was determined by the methods described by [9], acid value by the method described by [10] with slight modification, free fatty acids (FFA) was determined by the standard methods of (AOAC, 2000[12] and saponification value was determined by the methods described by [11].Proximate composition was determined by methods described by (AOAC, 2000[12].

Physical Properties

The physical parameters of the oil sample species which include refractive index(RI), smoke point, Viscosity, density and color were determined by the standards methods described by (AOAC, 2000[12] and AOAC, 1990[9].

RESULTS AND DISCUSSIONS

Table-1: Chemical Properties of the Oils

Sample	Oil Content (%)	Iodine value	Free Fatty Acid	Saponification Value	Acid Value
Earthnut	43.7	43.72±0.21	3.01±0.21	187±0.61	6.86±0.15
Pygmy	42.8	84.59±0.20	2.26±0.1	185.13±1.25	3.0±0.12
Pignut	45.8	88.52±0.26	1.32±0.06	201.4±0.45	2.44±0.15

The marketability of oil seeds as industrial raw materials for the production of edible oil for domestic purposes and as well as for industrial purposes can only be achieved through the determination of the quality of oil. To arrive at an informed decision in terms of the quality of oil or otherwise, some parametric factors should be considered. In line with this, the physicochemical analysis of the oil sample was carried out and this is shown in Table 1 and in Table 2.

From Table 1, pignut was showed the highest value of45.8% in terms of oil content above the earthnut and pygmy nut which showed the values of 437% and 42.8% respectively.

Iodine value is an essential component in the determination of the quality of the oil for domestic purposes. In this regards, the iodine value analysis carried out on the three species showed that pignut nut has the highest iodine value of 88.82±0.26, whereas pygmy has the value of 84.59±0.20 and the specie with least iodine value is earthnut having the value of 43.72±0.21.

From the results of the iodine value for the species under investigation, it could be observed that, earthnut and pygmy fall within the category of non-drying oil (9^oC-65^oC) whereas pignut constitutes oils that are classified as drying oil having iodine value within the range of (85^oC-150^oC).This may been as pignut having a high percentage of unsaturated free fatty acids in comparison to the other two species under the present investigation.

Saponification value (SV) is also a measure of the amount of saturated acids which is essentially of purely industrial significance rather than for nutritional purpose. Again from Table 1, the specie with the highest SV is the pignut with the value of 201.4±0.45, and the values of 185.13±1.25, 187±0.61 are value obtained from V analysis for pygmy and earthnut respectively. From the results, all the species can be harnessed economically for soap production depending on the end user demand of the products that could emanate from the oils.

Acid value furnish information on the on the usability of the oil for cooking purposes. Researchers[13] are of the opinion basically emanating from prudent laboratory analysis that the most suitable oil for cooking/frying should have acid value as low as possible within the range of (0.00 to 3.00mg/g).This in agreement with studies conducted by[14].

In line with the above view, and in tangent with quality values for domestic oils, pygmy and pignut have values 3.01±0.12 and 2.44±0.15 respectively. Earthnut with the highest value of 6.86±0.15 is beyond the range of oils for cooking purposes.

For domestic purposes, these results may imply that pygmy and pignut are the most suitable for use domestically for cooking/frying purposes. This may again imply that earthnut is most suitable for purposes other than cooking or frying as carrier in paints, and as a thermo-liquid.

As was deducted from literature, iodine value is a measure of the degree of unsaturation and fats, the value of which gives a measure of the vulnerability of oils to autoxidation. Higher values in terms of iodine values invariably implies high amounts of fatty acids and low smoke point. Unsaturation and more fats available for auto oxidation. The implication of this result is that, in terms of domestic use for either cooking/ frying, earthnut stands out as the best oil for utilization domestically.

For the industrialist, the challenge, is to either consider blending of these oil sample with a more health friendly variety or go outwardly for the cultivation and utilization of only earthnut, as it has been shown to exhibit better iodine value and therefore less prone to auto oxidation a requisite property for use either as a domestic cooking/frying oil or as a carrier for paint manufacturing industries.

As for the determinations of free fatty acids, the results indicate that the pignut specie has the lowest FFA value of 1.32±0.06, while earthnut has the highest value of 3.01±0.12 and pygmy nut coming next to earthnut with the FFA value of 2.26±0.10.

For good and efficient use of oil low free fatty acid values is a requirement. Higher FFA values will

imply that, the oil sample has very high fat which could contribute its deterioration at elevated temperatures.

On the other hand this could mean more loss of oil during oil refining processes and this may lead to high cost of production. In this case the production processes may require extraneous purification process.

As it is, the FFA value is a measurement of oil quality and less ease of deterioration either as in the shelf life or when exposed to heat, the less ease for autooxidation. The chemical analysis of these species is opening a new frontier as to comparatively efficient usage of various rather than only one of the species.

Table-2: Physical Properties

Sample/property	Colour	Smoke Point(^{0}C)	Viscosity(cSt)	Density(g/cm^3)	Refractive Index
Earthnut	Brown	212.50±0.61	39.06 ±0.02	0.918±0.20	1.50±0.0820
Pygmy	Dark brown	213.05±1.25	39.05±0.01	0.920±0.03	1.460±0.080
Pignut	Brown	214.47±0.45	40.05±0.13	0.918±0.020	0.501±0.080

The physical parameters of the oil samples are shown in Table 2. From the table, it was observed that the colour of all the species were brown, indicating the presence of unsaturation or double bond system.

The smoke of pignut was relative high showing a value of 214.50±0.61, this is closely followed by pygmy nut with a value of 213.05±1.25 and lastly earthnut 212.50±0.61.These observed disparity may not be unconnected to the fact that, there exist an interdependent scientifically proven inverse relationship between the smoke point and the amount or degree of free fatty acids. In this, for higher smoke point to result, the oil sample must be low in the amount of free fatty acids, which results in a corresponding increase in the smoke point. This is in parity with the studies of [15] in which studies attributed the low free fatty acid contents of seed oils to high smoke point.

To be able to profoundly characterized oils for economically gainful source of commerce and industrially a beneficial new comer, the viscosity or flow pattern of the oil samples were carried out. These in an attempt to, furnish the industries with the flow behavior of the material under study. Literature reveals that the flow property of oil sample is a function of its molecular weight distribution.

From the table, the viscosity of pignut was observed to the 40.50±0.13 which was followed closely by pygmy with a value of 39.5±0.01 and earthnut 39.06±0.02.The viscosity of the values of the oil seeds were higher than the values for soya beans (31cSt), cotton seed oil (36cSt), however the values are lower compared to the value reported for sunflower (60cSt) as in the studies of [16].

For density, the value of approximate(0.920 g/cm^3) except for earthnut and pignuts which showed a value of 0.918 g/cm^3.This value compares favorably with T.Occidentalis oil but lower than neem seed oil value of 0.9890.918 g/cm as eas reported in the studies of [17].

The (RI) is an indication of the degree of interaction between the oleic acid content and the linoleic acid content of the oil. In line with this, higher values of RI may serve as an indication of higher free fatty acid contents and consequently, the amount of free fatty acid present and vice versa.

From Table2, it was observed that the value for the refractive index for the three species under investigation was approximately 1.5 which falls within the acceptable range of 1.5-2.0 for conventional oils. The values were however higher than that of soybean (1.460-1.470) and palm kernel(1,449-1,451).This was slightly higher than that of occidentalis (1.460).The value of RI is indicative of the number of the number of carbon atom in the free fatty acid chains. The numbers of which, increase with increase in the number of double bond system as reported in the studies of [18].

To the industry, the implication of this result is that, more cost will be incurred during the production processes as steps have to be taken to ensure the lower of Free fatty acid content so as to recover the maximum amount of oil from the seed or even consider blending of the oil samples to achieve better properties. Although, these values may prove productive for those nursing the ambition for using seed oils for oleo chemicals and as sources of energy.

The elemental composition for the three species of groundnut is given in table 2 below. This is to advance an understanding of the nutritional and other food related properties of the groundnut species.

From the table, it can be seen that, on a general basis, the sodium and potassium are present at very high values in all the species under study with Earthnut having the highest amount of Na (42.00±0.71) and the lowest in terms of sodium content is pignut, having a value of (40.21±0.6).From literature, it was learnt that, sodium is essential for proper functioning of the body. Sodium helps in lowering the blood pressure thereby reducing the the risk of heart related diseases. These

suggest that the species of ground can be processed along with other food materials eaten raw.

An equally important mineral in this respect is potassium. Potassium is also essential for the maintenance of normal body growth and proper functioning of vital organs for instance, the liver, kidney and other vital body organs.

Pignut has the highest concentration of potassium of the three species under the current investigation.

For Magnesium, the three species of groundnut under this investigation showed 3.98±0.04, 4.38±0.8 and 5.61±1.5 for earthnut, pygmy and pignuts respectively. Pignuts have the highest concentration of magnesium.

For proper functioning the stomach and useful bone development, a substantially reasonable amount of magnesium is needed.

Calcium is an essential mineral responsible for the development of blood clotting properties, muscles contraction and certain other enzymatic metabolic processes. In line with this, the results for the elemental analysis of the three groundnut samples showed that Earthnut has a value of 2.28±0.62, 4.48±0.2 for pignuts and 3.32±0.6 for pygmy respectively.

In the case of iron, results of elemental analysis showed the highest value of 6.97±0.62 for earthnut, with pygmy nut second with a value of 6.85±0.42 and pignuts has the lowest value of 4.67±0.7. This is an indication that in terms of nutrients, and in line the importance of iron as a mineral needed for nourishment, pignuts has the lowest nutritional value in terms of iron content.

In the same vein, zinc was also one of the minerals detected in the analysis, the results of which showed that earthnut has the highest value of 3.20±0.11, having a close value of 3.00±0.5 and lowest value is the pygmy nut with a value of 2.35±0.22. Zinc is a mineral also needed in sufficient quantities for proper functioning of the biological systems of the body.

Analysis of the varieties of the oil sample also indicated the presence of Phosphorus, the presence of which is an indication of the richness of a particular oil type in mineral responsible for bone formation. This is also shown in Table 3.

From the table it can be seen that, earthnut and pignut have the lowest value of 10.55±0.68 and 10.30±0.24 and the highest of 11.20±0.2.

Table-3: Mineral Contents in (mg/100g) of Groundnut Oil Species

Sample/ Element	Earthnut	Pygmy	Pignut
Na	42.00±0.71	41.21±0.4	40.21±0.6
K	60.7±0.5	62.4±0.5	63.1±0.7
Mg	3.98±0.04	4.38±0.8	5.61±1.5
Ca	2.28±1.62	4.48±0.8	3.32±1.8
Fe	6.97±0.62	6.85±0.41	4.67±0.7
Zn	3.20±0.11	3.00±0.5	2.89±0.22
P	10.55±0.68	11.2±0.2	10.30±0.24

Table-4: Proximate Composition of the Groundnut Species

Proximate parameter/Specie	Earthnut	Pygmy	Pignut
Crude Fibre	3.7±0.03	3.7±0.3	3.00±0.4
Carbohydrate	1.81±0.04	1.81±0.02	1.3±0.3
Fat	47.00±0.03	46.7±0.8	44.21±0.4
Ash	3.8±0.06	3.98±0.43	3.3±0.6

For a more detail and in depth comparative understanding of the properties of the three species under investigation, proximate analysis was carried out and the results of the analysis is shown in Table4.From the table,

From the table, the value for the crude fiber was the same for both earth nut and pygmy (3.7±0.3) except for pignuts which showed a value of 3-00±0.4.This is an indication that it is good in dietary fiber and helps in the reduction in constipation.

Carbohydrate value for earthnut and pygmy nut are 5.8±0.4 and 5.2±0.1 respectively. While pignut has a value of 4.89±0.2.The overall values for the three species investigated is lower than that of *Citrillus vulgaris* seeds value of 14.60±0.03 as reported by [19] and S*esame indicum* which has the value of 13.60±0.02.

Analysis on the fat contents of the three species showed that earthnut has a value of 47.00±0.03, pygmy has a value of 46.7±0.8 and pignuts 44.21±0.4.These values were however higher than the values reported elsewhere by the researchers [1,

20].This may be an indication of improved shelf life and increase oil yield in terms of processing and the flavor of the stored oils.

To advance an understanding of the of the nature of material present in the oil and to investigate the nature of inorganic present in the oil sample, ash content or mineralization of the sample was carried out. From the result pygmy nut has the highest ash content of 3.98±0.43, this closely followed by earthnut with a value of 3.8±0.06 and lowest in this case is the pignut with a value of 3.3±0.6.From the results, pygmy nut constituted a good source of mineral rich components and has more impurities as in the studies [21]

Furthermore, the ash content value exhibited by the three species, clearly indicate the presence of inorganic materials and could have contributed in the high values of the elements considered earlier considered for analysis.

CONCLUSION

Collecting from the results of the investigation carried out on the three species under the present study, the following conclusions could be made as follows;

- For economic purposes, the comparative advantage in terms of the amount of oil shows that the species could collective or individually sourced and harnessed economically for their oil.
- For domestic as well as industrial utility of the oil obtained from the three species, pignut stands out as the best specie that could be maximally owing to its high smoke point and high free fatty acid value.
- for nutritional purposes, with regards to food making industry, and judging from the elemental point of view, the species could be safely exploited for food for the fortification of food and finally,
- (iv)Due to the resilience, viscosity properties and relative thermal stability of the species studied, they could me effectively harnessed for use as thermo liquids.

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