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Effect of drying temperatures on proximate composition of African bush mango seed flour and physicochemical properties of the oil

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Abstract

The effect of drying on the proximate composition of African bush mango seed flour and physicochemical properties of extracted oil were evaluated. Two types of African bush mango seed which were used for the analyses *were Irvingia wombulu and. Irvingia gabonensis.* The seeds were dried at different temperatures of (40, 50, 60 and 70^{o}C) in the oven for 1h. After drying it was milled into flour and the extraction of oil was done using standard method. The result for the samples for moisture content ranged from (2.25 -2.50% and 2.25%- 4.25%), crude fibre (13.00 - 16.75% and 15.02%-16.70%), fat content (40.80-49.0% and 43.85-49.30%), crude protein (4.65-8.69% and 12.10 - 12.90%), ash content (2.40 -3.50% and 1.97 - 2.66%), carbohydrate (23.80% - 30.50% and 18.80% - 21.70%) for *I. wombulu and I. gabonensis* respectively. The moisture content decreased with increase in temperatures. Crude fibre, fat, ash, and protein increased significantly ($p>0.05$) for the two samples at different levels of temperatures. The result for the physicochemical properties of the oil for the two samples for saponification value ranged from (154.980-173.80 and 159.580- 170.107) mgKOH. Iodine value (161.235- 162.150 and 155.225 - 160.310) mg I2/g. Peroxide value (1.235 – 1.245 and 1.315 – 1.350) Meq/Kg, acid value (19215- 19.915 and 18.435- 18.885) mgKOH. Free fatty acid (9.610 – 9.960 and 9.221 – 9.765) and refractive index values (1.460-1.470 and 1.519- 1.578). The two samples showed high saponification value, iodine value and acid value. These high values is an indicator for suitability for use in the paint and soap industries. Also the increase in ash and carbohydrate content makes it a good source for mineral and energy.

Keywords: African bush mango; Proximate composition; Extraction of oil; Physicochemical properties; Temperature variation

1. Introduction

The bush mango (*Irvingia gabonensis*) *belongs* to the family, Irvingiaceae and it is commonly called African bush mango, wild mango or Dikanut (Ekundayo *et.al*., 2013). The African bush mango is a special type of mango grown for its edible pulp. Irvingia species seeds are the most valuable products of the tree and have the most industrial potential. The crude fat content is 62.5% (Kengni *et al*., 2011) proving them to be very good oil seeds. The seeds also contain ash, moisture, protein, fat, fiber, carbohydrate, and the predominant mineral is magnesium. Bush mango has good nutritive value and is a good source of energy, vitamin A and C. Fat produced from nuts of bush mango are used for various purposes and has the potential to be used in different pharmaceuticals, confectionery and cosmetic uses (Odewale *et al.,* 2015) . *Irvingia gabonensis* fruit is a broadly ellipsoid drupe; yellowish and having very juicy fibrous pulp when ripe. Its stony nut encases an oil rich dicotyledonous kernel wrapped inside a brown seed-coat (Ogunsina *et al.,* 2008). *Irvingia garbonensis var* excels seed yields about 72% fat with a low iodine value, and high in saponification value (Ogunsina *et al.,* 2008). This makes it suitable for the oil to be used in soap manufacture, cosmetics, pharmaceuticals, margarine and for cooking oil. The kernels of *Irvingia garbonensis var excels* yields about 54 – 68% of an almost solid or pale yellow fat which is being used experimentally in Europe for the production of margarine and cocoa fat substitutes (Ngondi *et al*.,

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2009). (Bello *et al.* 2011) showed the possibility of *I. gabonensis* kernel oil as a biofuel to be used as alternative fuel for diesel engines. Looking at the current consumer trend towards healthier lifestyle and the mistrust of bioengineered oil seeds, edible oil suppliers may in future turn to tropical oil seeds that are both low in saturated fat and met stability criteria. Thus, it is envisaged that *Irvingia garbonensis* var *garbonens* seed oil may be a new source of edible oil which may find potential application in the food processing and food service industries (Agoha, 2005).

The focus of this study is to determine the effect of drying of African bush mango seeds on the flour proximate composition and physicochemical properties of extracted oil as a step to extending its exploitation in human food systems, enhanced its utilization in food industry and to prevent waste related to environmental hazard.

2. Material and methods

2.1. Source of Materials

Samples of African Bush Mango (*Irvingia gabonensis* and *Irvingia wombulu*) were purchased from new market Wukari Taraba State, Nigeria and conveyed to the Food Science and Technology laboratory for analysis.

2.2. Sample Preparation

The seeds were sorted in the laboratory to remove extraneous materials and dried at different temperatures of (40, 50, 60 and 70^{0}C) in the oven for 1h. After drying it was milled into flour and sieved using 1mm sieve mesh. The milled samples was separately packed in an air-tight plastic containers prior to analysis.

2.3. Determination of the percentage of the oil extracted (oil yield)

The extraction of oil from African bush mango seed flour was done using continuous Soxhlet extraction method as described by (Kittiphoom and Sutasinee , 2012). Thirty gram (30 g) of the sample was mixed with three hundred (300 ml) of petroleum ether in a round bottom flask, heated at a temperature of 40-60^{o}C for 3h .The experiment was repeated for different weights of the sample, 35, 40 and 50 gram. At the end of extraction, the percentage of oil extracted was calculated as; Oil yield = weight of oil before extraction- weight of oil after extraction ×100 / Weight of the seed before extraction.

2.4. Proximate Composition Analysis

The ash content was determined by the furnace incineration method of AOAC (2010). The semi-continuous solvent extraction method of Pike (2003) was employed in the fat determination. The crude fibre and moisture content was done by the gravimetric method of AOAC (2010) . Protein content of the sample was determined by the Kjeldahl method in which the total nitrogen (N_2) was determined and the factor (6.25) was used to obtain protein as reported by Udensi and Oyewer (2005). All analyses were carried out in duplicates**.**

2.5. Physicochemical properties of seed oil:

The acid value, free fatty acid, saponification value and iodine value were determined by the alkaline titrimetric method as described by Ikya *et al* (2013). The peroxide value was determined as the milli-equivalent of peroxide per unit weight of the oil as described by Pike (2003). Colour index (refractive index) was determined by the spectrophotometric method of AOAC (2010).

2.6. Determination of calorific content (Energy value)

Calorific content was calculated using water factor method as described by AOAC (2010). The values obtained for protein, fat and carbohydrate were used to calculate the calorific content of the samples as expressed below: Calorific value (kcal/100g) = (P×4.0) + (F×9.0) + (C×3.75).Where protein content (%) = P, Fat content (%) = F and carbohydrate content (%) =C

2.7. Statistical Analysis

All analyses were carried out in duplicates and subjected to one-way Analysis of Variance (ANOVA) at 95% confidence level, means were separated using Duncan Multiple Range Test using the Statistical Package for Social Sciences (SPSS 21.0).

3. Results and discussion

3.1. Effect of drying temperatures on the proximate composition of African bush mango seed flour

The effect of drying on the proximate composition of African bush mango seed flour (Irvingia wombolu and Irvingia gabonensis) is presented in Table 1. The moisture content ranged from 2.25% - 2.50% and 2.25% - 4.25% at temperatures of 40oC, - 70oC respectively, The moisture content decreased with increase in temperatures. This result is within the range value of most seeds and legumes as reported by Samaram et al (2015). The low moisture content will prevent microbial spoilage thereby prolonging the shelf life of the flour. The crude fibre levels ranged from (13.00 - 16.70%, and 15.02%. – 16.70%), the crude fat values (40.80%, - 49.80% and 43.85%, - 49.30%) at temperatures of 40oC - 70oC respectively. The crude protein ranged from (4.65% - 8.69% and 12.10% - 12.60%) at temperatures of 40oC,-70oC respectively. The ash content (2.40%, - 3.50% and 1.97% - 2.66%) at temperatures of 40oC - 70oC respectively. The carbohydrate content (23.80%-30.50% and 18.80% - 21.70%.) at temperatures of 40oC, - 70oC respectively. Crude fibre, fat, ash, and protein increased significantly (p>0.05) for the two samples (I.W and I.G),at different levels of temperatures. These results obtained from this study compared favourably with the report of other workers (Aremu et al., 2011) who obtained a similar result for Bambara nut, walnut flour and quinoa flour Ogungbenle (2009.). The high increased in fiber contents may be due to increase in temperatures. The high fibre content may improve bowel function and provide fecal bulk digestion. It has been reported that intake of high dietary fibre can lower cholesterol level, risk of coronary heart disease, hypertension, diabetes and breast cancer (Ramola and Raw, 2003) .The increased crude fat values may qualify African bush mango as oil -rich seeds and thus making it a good source of quality edible (vegetable oil) for both domestic and industrial uses. The increase in ash and carbohydrate content makes it a good source for mineral and energy.

The crude protein Irvingia wombolu and Irvingia gabonensis ranged from 4.65 - 8.69% and 12.10 - 12.60% at temperatures of 40-70oC respectively. The crude protein value for I. wombolu is low compared to some commonly consumed plant protein in Nigeria and the result of this study is in agreement with the report of Bampouli et al (2014) where they reported a lower protein of 7.47 ± 0.81 %. The observed low value in this study may be due to long lasting storage condition and the temperature variation effect of oven drying. A higher result obtained from this research work for protein is in agreement with the research carried out by Bampouli et al (2014) on African bush mango for Irvingia gabonensis.

The ash content for I. Gabonensis was low, but these values obtained were similar when compared with the work of Danlami et al (2014) which reported a mineral ash of 2%. The high carbohydrate content obtained in this study is in agreement with the work of (Ogungbenle, 2009) who had a similar result of (29.9%) .This shows that the sample is a good source of energy.

Table 1 The effect of drying temperatures on the proximate composition of African bush mango seed flour

Sample T(°C)	Moisture content (%)	Fats (%)	Ash (%)	Protein (%)	Fiber (%)	Carbohydrate (%)	Energy (kJ/100g)
I.W 40	2.25±0.35[C]	40.8± 1.06[C]	3.50±0.71[a]	8.69±0.07[b]	14.75±0.35[c]	30.50±0.71[ab]	2192.2
I.W 50	2.50± 0.71[bc]	46.0±0.72[cd]	2.40± 0.07[bc]	7.47± 0.05[c]	16.70±0.49[a]	25.50±0.78[c]	1861.5
I.W 60	2.25± 0.35[c]	47.6± 0.85[b]	3.03± 0.04[ab]	4.65± 0.07[d]	13.00±0.07[d]	29.50± 0.42[a]	750.8
I.W 70	2.05± 0.07[c]	49.80±0.42[a]	2.47± 0.05[bc]	6.95± 0.07[c]	15.00± 0.07[bc]	23.80± 0.71[d]	2389.9
I.G 40	4.35± 0.35[a]	43.85± 0.92[d]	2.17± 0.22[c]	12.60± 0.78[a]	15.95± 0.07[ab]	21.20±2.26[b]	2216.9
I.G 50	3.25± 0.35[b]	44.85± 0.21[d]	2.03±0.62[c]	12.3±0.35[a]	15.95± 0.07[ab]	21.70± 2.42[b]	2257.9
I.G 60	2.25± 0.35[c]	47.00± 0.57[bc]	2.66±0.06[bc]	12.9± 007[a]	16.70± 0.92[a]	18.80± 1.83[c]	2300.4
I.G 70	2.25± 0.35[c]	49.30±0.78[bc]	1.97±0.06[c]	12.10± 0.28[a]	15.2±0.78[bc]	20.60± 0.00[a]	2403.8

Value is mean ± standard deviation of replication. Mean with different superscripts within the column are significantly different (p>0.05) I.W= Irvingia wombolu, I.G = Irvingia gabonensis, TOC = Temperature

3.2. Effect of drying on the yield of the extracted oil from African bush mango seed

The effect of drying on the yield of the extracted oil from African bush mango seed Irvingia wombolu and the Irvingia gabonensis is presented in Table 2 the yield ranged from 60-80% and 70-88% at temperatures of 40 - 70oC respectively .The results obtain from the study revealed that as the temperature increases the volume of the oil yield increases for both samples analyzed. The result of this study when compared with the work of Necla et al (2018) in terms of oil yield shows that oven drying method at various temperatures may have contributed to a higher yield of oil when compared with oil obtained from sun drying which had lower yield (Necla et al.,2018).

Table 2 The effect of drying on the yield of the extracted oil from African bush mango seed

Samples	**Temperature (^{0}C)**	**Yield (%)**
Irvingia wombulu	40	60
Irvingia wombulu	50	70
Irvingia wombulu	60	74
Irvingia wombulu	70	80
Irvingia gabonesis	40	70
Irvingia gabonesis	50	76
Irvingia gabonesis	60	86
Irvingia gabonesis	70	88

3.3. Effect of drying on the physicochemical property of the extracted oil.

The effect of drying on the physicochemical properties of oil extracted from *I. wombulu and I. gabonesis* are represented in Table 3. “Saponification value (SV) indicates the average molecular weight and hence, chain length. It is inversely proportional to the molecular weight of the lipid” Aremu *et al* (2013). Saponification value obtained from this study ranged from 154.980, - 173.805 and*,* 159.580, -170.107 mg/KOH/g at temperatures of 40^{o}C -70^{o}C respectively for both samples anlysed. The saponification value obtained from this study was higher when compared with the earlier report by Arisanu,(2013) for oil extracted from fluted pumpkin seed, with saponification value of 162 mg/KOH/g. However, the saponification value obtained in this study was greater than the one obtained by Takadas and Doker,(2017) for Oleander oil*.* which ranged between 121.7-124.3 mgKOH/g. “High saponification values indicate high proportion of lower fatty acid. This high value indicates that the oil could be used in the manufacture of soap” Kirschenbauer,(1995). The result for the *I. wombulu(I.W) and I. gabonesis(I.G)* seed oil is below Codex standard for cotton oil (189 - 198 mg KOH/g), soybean oil (189 - 195 mg KOH/g), corn oil (187 - 195 mg KOH/g) and peanut oil (187 - 196 mg KOH/g) Codex Alimentarius Commission (1993).

“Iodine value is the number of milligrams of iodine absorbed by one-gram fat and it gives an indication of the number of double bonds in any particular oil or fat. Lipids with poly unsaturated fatty acids are easily assimilated and broken down to produce calorific energy than saturated fatty acids. Also, lipids with high iodine value have low stability because it can easily undergo oxidation. However, the iodine values for the seed oil of *(I.W) and (I.G)* ranged from 161.100-161.265 and155.225, - 160.310 g/100g at temperatures of 40^{o}C-70^{o}C respectively. The high iodine value of seed oil obtained from this research agrees with the report of Takadas and Doker,(2017) for Oleander oil. Oils with iodine value above 125 mg of I/100 g are classified as drying oils; those with iodine value 110 – 125 mg of I/100 g are classified as semi drying oils. Those with iodine value less than 110 are considered as non drying oil Alakuru, et al (2017) Thus, the seed oil of *(I.W) and (I.G) which* has high iodine value, is classified as drying oil and can easily undergo oxidation. Hence, oil of *(I.W) and (I.G)* can be of great use to paint and coating industry since it is a drying oil.

“Peroxide value is used to quantify the extent to which rancidity reactions have occurred during storage. It could also be used as an indication of the quality and stability of fats and oils” Zang et al(2017). “It depends on factors such as state of oxidation, method of extraction and type of fatty acid present in the oil. Peroxide value obtained from this work ranged from 1.235- 1.250 and 1.345 and 1.315 – 1.350 meq/kg at temperature of 40^{o}c, -70^{o}C respectively. Both values fall within the FAO/WHO standard for vegetable oil which is <10 meq/kg (Codex Alimentarius Commission (1993). The peroxide values are also very low, indicating that both oils would be stable to oxidative degradation.

The result obtained for the peroxide value of the samples analysed are lower when compared with the peroxide value of groundnut oil and refined olive oil which recorded a value of 9-11meq/kg respectively (Arisanu,2013). Also other workers like Aremu *et al* (2022) had lower peroxide value of 3.82 and 5.90 meq/kg from *Balanites aegyptiaca* kernel and pulp oils.

Acid value is a measure of the free fatty acids in oil. The higher the acid value found, the higher the level of free fatty acids which translates into decreased oil quality. "Acid value is also used as an indicator for edibility of an oil and suitability for use in the paint and soap industries" Aremu *et al* (2006). Acid values obtained from this study ranged from 19.215-19.910 - and 18.435, -18.885 mg/KOH/g at temperature of 40ºC- 70ºC respectively. The highest acid value of 19.910 mg/KOH/g was obtained at 60ºC temperature. This increased in acid value could be due to relative rise in temperature during extraction, processing or storage. This also indicates that the oil will not go rancid if properly handled. The result obtained from this study agrees with the report of Odewole *et al,* (2015) for oil chemically extracted from fluted pumpkin seed with petroleum ether. The acid value of oil gives an indication of whether the oil can be edible or not especially when the value is below the desirable limit. Oils are classified as edible when the acid value does not exceed 4 or above 5mgKOH/g (Bello *et a*l., 2011and Audu *et al*., 2013).

Free fatty acid (FFA) ranged from 9.610 - 9.960 and 9.221- 9.765 at temperature of 40 - 70ºC respectively. The high free fatty acid value obtained in the study is a bit higher than 3.42 mg/KOH/g reported by Bello *et al*, (2011) for palm kernel oil and was greater than between 0.61-0.62 mgKOH/g reported by Takadas and Doker,(2017) for Oleander oil. However, the relative increase in the amounts of free fatty acid can be attributed to the method adopted in the seed processing, duration of storage or drying of the seeds.

The refractive index of oil is a function of molecular structure and impurity. Refractive index provides a quick and easy method to identify oil and determine its purity Alakuru *et al* (2017). Refractive index values obtained from this study ranged from 1.460- 1.470 and 1.519-1.578 seed oil of *(I.W) and (I.G)* at temperature of 40 - 70ºC respectively. The value of refractive index of the oil obtain in this study agrees with the values obtained by Dutta and Mukherjee, (2015) within the range of 1.470-1.578 for some fats in the nuts family. Also, the above result agrees with the refractive indices of many vegetable oils. Hence both oils cannot be easily adulterated (Ariponnammal,2012). The refractive index shows the degree of purity of the oil.

Table 3 The effect of drying on the physicochemical properties of the extracted oil

Sample T(˚C)	**S.value (mgKOH/g)**	**Iodine value (g/100g)**	**P.oxide value (mmolO_2/g)**	**Acid value (mgKOH/g)**	**F.F.A value (% oleic acid)**	**R.index (20˚C)**
I.W 40	154.980[c]±0.99	161.235[b]±0.05	0.245[a]±0.01	19.915[a]±0.04	9.960[a]±0.01	1.470[a]±0.00
I.W 50	160.990[a]±0.99	161.265[b]±0.02	1.250[a]±0.00	19.215[b]±0.05	9.610[b]±0.03	1.460[a]±0.00
I.W 60	170.405[b]±2.98	162.100[a]±0.00	1.240[b]±0.00	19.910[c]±0.03	9.960[c]±0.01	1.465[a]±0.01
I.W 70	173.805[a]±4.94	162.150[a]±0.00	1.235[b]±0.01	19.555[d]±0.08	9.780[d]±0.04	1.460[a]±0.00
I.G 40	161.350[c]±0.99	156.215[b]±0.04	1.345[a]±0.01	18.515[a]±0.02	9.324[a]±0.02	1.578[a]±0.00
I.G 50	159.580[a]±0.99	155.225[b]±0.01	1.350[a]±0.00	18.435[b]±0.01	9.654[b]±0.01	1.541[a]±0.00
I.G 60	160.405[b]±1.98	160.100[a]±0.05	1.320[b]±0.00	18.620[c]±0.03	9.765[c]±0.01	1.519[a]±0.01
I.G 70	170.107[a]±2.94	160.310[a]±0.04	1.315[b]±0.01	18.885[d]±0.03	9.221[d]±0.06	1.521[a]±0.00

4. Conclusion

The result obtained from this study revealed that the drying of the seed of the African bush mango (*I. Wombolu* and *I. gabonensis)* lead to the increase in ash and carbohydrate content which is an improvement in the nutrient composition of the seed flour which makes it a good source for mineral and energy. The oil obtained from the seed flour can be of great use to paint , soap, pharmaceutical and coating industries due to its high acid value, iodine value, saponification value, and also it is a drying oil.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest.

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