



Effect of Moisture Content on the Yield of Mahogany Seed Oil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

African Mahogany (*Khaya senegalensis*) is an important tree in Africa. A deciduous tree, reaching up to 35m in height on fertile soils. It has a diameter of up to 1.5 m with 8-16 m bole. The bark is dark grey or pink with red latex. The plant is commonly found in all the Northern States and around South Western States of Nigeria in the rain forest zone. The plant begins to produce fruit after 15 – 25 years throughout the dry season. The fruit is woody capsule, 4-10 cm long and dehisces at maturity. The seeds have a very low moisture content which is good for oil extraction hence its selection. For the purpose of this study, Mahogany seed, distillation apparatus, jaw crusher, water distiller, chiller, soxhlet extractor, oven, digital weighing balance, n-hexane, are the materials used for the extraction. According to Soxhlet procedure, oil and fat from solid material are extracted by repeated washing (percolation) with an organic solvent, usually hexane or petroleum ether. 325 g of mahogany seed was used in 25-x 80-mm thimble. The Sample has an oil yield of 63.58%, with a cake of 206.62g after extraction and a moisture content of 9% as a result of volatile substance due to high vapor pressures. Further studies on the extraction of oil from mahogany seed is recommended with method other than soxhlet extraction method using n-hexane as extracting solvent as the best method of extraction for end users.

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1. INTRODUCTION

Due to increasing demand, cost of fossil fuel and environmental degradation, alternative source of diesel have to be found to replace the fossil diesel. Oil from African *Mahogany* (*Khaya senegalensis*) as a non-edible oil and a good source of biodiesel comparative to *Jatropha curcus* which was tried in a crude form by Rudolph Diesel thus the name diesel [1]. Oils from these plants are highly viscous, about 17 times higher than fossil fuel, therefore biodiesel can be produced by the transesterification of vegetable oils, especially non-edible oils to avoid competition and scarcity with food [2].

“The plant Mahogany (*Khaya senegalensis*) is an important multipurpose tree in its natural range in Africa and Madagascar” [3]. “A deciduous tree, 15-20m tall, reaching up to 35m on fertile soils with a diameter of up to 1.5m and a clean bole of 8 – 16m. The bark is dark grey with a dark pink slash and red latex. It has a compound leaf of up to 20 cm long, with 3-7 pairs of usually opposite leaflets, each leaflet is 7-12 cm long, 3-5cm wide, underside grey. The flowers are small, about 5 mm, with white petals; unisexual, but with well-developed vestiges of the opposite sex, making it difficult to distinguish between male and female flowers. Flowers are borne on up to 20cm long, much branched inflorescences. All species become big trees, 20 – 35m tall with a trunk over 1 m in diameter, often buttressed at the base. The plant thrives well in riverine forest and scattered in high rainfall Savannah woodland with 700 – 1750mm rain/year and a dry season of 4 – 7months” [4]. “The plant is commonly found in Northern Nigeria and around Lagos, Ogun, Edo, Osun and Oyo states in the rain forest zone, while in the middle belt it is found around Niger, Benue, Adamawa and Taraba states” [5]. “The plant begins to produce seeds when they are 15 – 25 years and in most places, fruiting is regular and the fruits remain on the tree for most of the dry season. The plant is rated as one of the best for timber due to the hard and moderately hard wood with a density of 0.6 – 0.8 g/cm. The plant is valued for its medicinal purposes, especially the bark, which is used to treat a number of diseases. The leaves have low forage value and are used at the end of the dry season” [4]. “In West Africa, particularly Nigeria, the seed oil is used for cosmetics, due to its high oil content of 67%, comprising 21% palmitic acid,

10% stearic acid, 65% oleic acid and 4% unidentified acid” [4].

“During the 20th century, the use of non-edible oil seeds products declined substantially due to availability of relatively and cheap oil derived from fossil reserves. Hence, looking into alternative oil source from various seeds remains a subject of active investigation” [6]. “Mahogany (*Khaya senegalensis*) seed is valued among the best in production of non-fossil oil used for various applications. Although, such oils are not expected to replace petrochemicals in their entirety, however, the processing of the seeds for the extraction of oil is mostly done conventionally and has great effect on the quality, efficiency and oil yield of the seeds”. [7] “As such the need to optimize the post-harvest production process which has not received significant engineering research like investigating the physical and mechanical properties of the seed that constitute an important and essential engineering data in the mechanization of its production, handling, processing and storage” [8].

The aim of this study was to determine the available quantity of oil per unit quantity of mahogany seeds and to justify its use as biodiesel. The study generated information and data that is useful in choosing the best potential method for extraction of oil from Mahogany seeds.

2. MATERIALS AND METHODS

The Mahogany seeds were collected from Michika a community in Adamawa state in the North Eastern part of Nigeria. The seeds were selected and separated from wastes and other debris manually. The selected seeds were placed in an oven at a temperature of 105°C for a period of 12 hours to dry or remove excess moisture; the mahogany seed were fed into a jaw crusher to crush the seeds to a particle size of less than 5 mm and higher than 0.2 mm. This increases the surface area of the seed and aid in good extraction. Oil Extraction using Soxhlet Method is the most commonly used semi-continuous process for the extraction of lipids from foods. According to Soxhlet procedure, oil and fat from solid material are extracted by repeated washing (percolation) with an organic solvent, usually hexane or petroleum ether. The n-hexane was used for the purpose of this work, using a modified Soxhlet extraction method with

an average of 325g of mahogany seed in 25 x 80mm thimble. Grounded Mahogany seed samples were placed in a porous cellulose thimble. The thimble was then placed in an extraction chamber which is being suspended above a flask containing the solvent and below a condenser. Heat was being applied to the flask and the solvent evaporates and moves to the condenser where it is converted into liquid that trickles into the extraction chamber containing the sample. The extraction chamber was made in such a way that when the solvent surrounding the sample exceeds a certain level it overflows and trickles back down into the boiling flask. The flask containing solvent and lipid was removed at the end of the extraction process. The solvent in the flask was separated via distillation and the mass of the lipid remaining was measured. The percentage of the lipid in the initial sample was then calculated. The process of solvent extraction is shown in Fig. 1.

2.1 Determination of Percentage of Oil Extracted

The percentage of oil yielded was calculated using the following relations

Initial mass of sample before extraction = 325g
 Final mass of sample (oil cake) after extraction = 206.62g
 Volume of oil after extraction = 90ml

$$\% \text{ Yield of oil} = \frac{w_1}{w_2} \times 100$$

Where

w₁ = mass of the cake after extraction
 w₂ = mass of the seed before extraction
 $\% \text{ Yield of oil} = \frac{206.62}{325} \times 100 = 63.58$

3. RESULTS AND DISCUSSION

3.1 Effect of Moisture Content on the Yield of Mahogany Seed Oil

The results obtained were used to determine the effect of the differences in moisture content on oil yield as presented in the table.

In the results of extraction analysis of the physical properties (Table 1) and the effect of variation in moisture content and yield of Mahogany oil (Table 2). The initial weight of the seed during the first trial was 325g with a density of 0.885mg/l with golden yellow colour. The volume of oil extracted was 90ml which represents 27.69% of the initial seed. According to Ibrahim Al et al. [9] using the mechanical pounding method of extraction other than soxhlet as employed in this research, oil yield of 73.56% which is higher than 90 mills (27.69%) as obtained in this research. The wide gap in yield could be attributed to the

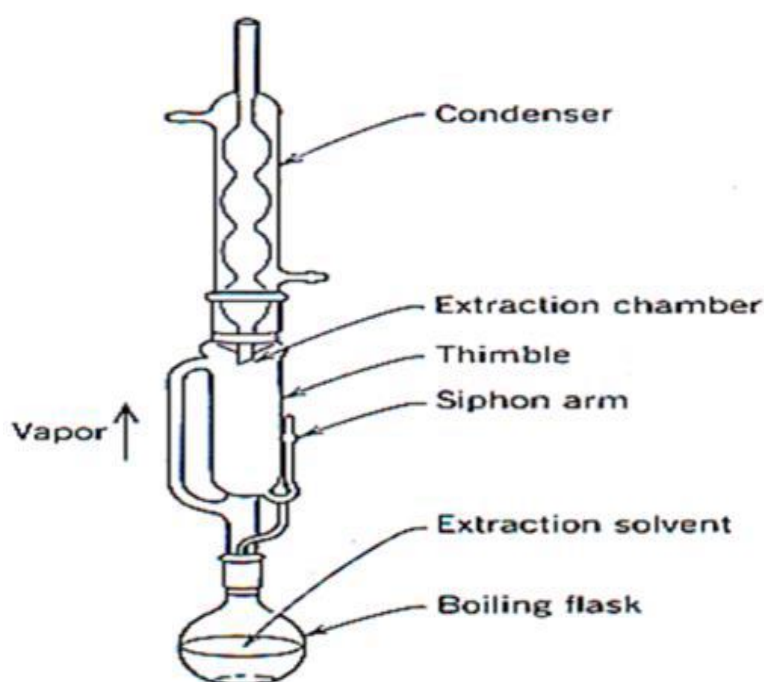


Fig. 1. Showing Soxhlet extraction apparatus

Table 1. Physical properties of mahogany oil extracted

S/no	Property	Value
1	Initial Weight of Mahogany seeds (g)	325
2	Density (mg/l)	0.885
3	Color	Golden yellow
4	Oil volume (ml)	90
5	Yield (%)	63.58

Table 2. The effect of variation in moisture content and yield of mahogany oil

Initial Quantity of seeds	Volume of oil (ml)	% Volume of oil	Quantity of cake (g)	% Quantity of cake	Moisture content (g)	% Moisture content	Color
325	90	27.69	206.62	63.58	30	9.23	Golden yellow
300	80	26.67	188.4	62.80	31.6	10.53	Light yellow
250	65	26.0	157.2	62.88	27.8	11.12	Light yellow
310	85	27.42	198.12	63.91	26.88	8.67	Light yellow

method employed in extraction. However, this result agrees with [10] who opined that 1400 (28%) mills of oil from 5000g of mahogany seed were obtained using the press method of extraction while the maceration method of extraction yielded 43%. The quantity of the residue (cake) was 206.62g representing 63.58% which is higher than 31.4 and 20.2% found in *Azadirachta indica* and *Carapa procera* despite a low ash content of 5.3 and 8.3 respectively [11]. This result shows that kernels with higher moisture content produce more oil than those with lower moisture content oil. There 90 mils of oil 30g of moisture (9.23%) higher than 65 mils of oil at 27.8g of oil (11.12%) this result contradicts [12], where the following of oil was obtained at different moisture content levels 22.37% oil yield gave (6.3% moisture content) 24.86% oil yield at a moisture content of 8.1%, 21.21% oil yield with moisture content of 13.2% and 16.6% moisture content yielded an oil of 15.6% the discrepancy could be attributed to method of extraction and differences in environmental factors of where the oil was extracted. However, the pattern of moisture content was consistent with [13] who reported that oil extracted from seed having 8.4% moisture content on wet basis was considered to be of good quality with a maximum extraction of 91.66% were obtained at 5.8% moisture content. The golden yellow colour is secondary factor. This is confirmed by the second and third trials respectively where extraction yielded less quantity oil where 300g of seed was used to produce an oil of 80g representing 26.67% with a cake of 188.4g (62.80%) with the highest moisture content of 31.6g (10.53%) but light yellow colour. The third trial used 250g of seed where only 65g (26.0%) of oil was generated as

the least quantity with a cake of 157.2g (62.88%) and a moisture content of 27.8g (11.12%) with light yellow color. The final trial with 310g of seeds yielded 85g of oil representing 27.42% with a cake of 198.12g (63.91%) with a moisture content of 26.88g (8.67%) and yellow colour.

There was no consistent pattern with the volume of moisture and quantity of seed. However, the highest moisture content of 31.6g (10.53%) was from 300g of seed and the least of 26.88g of moisture (8.67%) was from 310g. The value of volatile substances ranged from 0.0 to 0.80 with an oil 0.61g which is negligible and can be attributed to heating temp, period of experiment and environmental factors. This result agrees with [14] that extractable oil is influenced by moisture content of the seed similarly, [15] observed that in Sunflower oil was extracted using the batch system at 50°C using hexane and three moisture content levels 5.65%, 12.40% and 18.92% in a dry season. The increasing moisture content caused an increase in yield and total amount of minor compounds. Also using the screw press method oil yield is affected by moisture content of 0%, 1.2% and 20% and particle size of 0.81 min, 2.90 and 8.60 min. The average value of the four trials was 296.25g of seeds which yielded 80g of oil (26.95%) with a residue or cake of 187.59g (63.24%) and moisture content of 29.0g (9.89%) [16].

4. CONCLUSION

It can be concluded that oil from mahogany can be extracted using hexane as a solvent with a

golden colour as a reflection of the quality of the oil. The volume of extractable oil decreases with high moisture content in mahogany. In other plants like Sunflower and Pumpkin the highest yield of oil is obtained with increasing moisture content. Based on the number of trials as indicated in the second trial with 300g of seed yielding 80g of oil (27%) with 188g of residue (cake) (63%) and a moisture content of 29g (10%). The volatile substance was negligible.

5. RECOMMENDATION

Further studies on the extraction of oil from mahogany seed are needed with method other than Soxhlet extraction method using n-hexane as extracting solvent as the best method of extraction for end users. However, it is recommended that moisture content should be maintained to the barest minimum in order to achieve maximum yield of oil.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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