Research Article

Preliminary physicochemical analysis of extracted oil and pulverized seeds from underutilized savannah tree *Acacia sieberiana* (DC)

Abubakar Salisu¹*, Osuji Charles¹, Afolayan Michael², Adebiyi Adedayo², Mawobi Gebriel³

¹Biotechnology Advanced Research Centre, ²Chemistry Advanced Research Centre, Sheda Science and Technology Complex, P.M.B. 186, Garki, Abuja, Nigeria
³Nasarawa State University, Keffi, Department of Biological science, PMB. 1022, Nasarawa State, Nigeria

*For correspondence
Abubakar Salisu,
Biotechnology Advanced Research Centre, Sheda Science and Technology Complex, P.M.B. 186, Garki, Abuja, Nigeria.
Email: salisuabubakar99@yahoo.com

Received: 29 August 2016
Accepted: 16 December 2016

ABSTRACT

Objective: The research was carried out to preliminarily evaluate the physicochemical and quality assessment of extracted oil and pulverized seeds of underutilized tree *Acacia sieberiana* growing in Sub - Sahara part of Nigeria.

Methods: The oil was extracted using hexane as a solvent of extraction, adopting the method described by Association of Official Analytical Chemist. The properties of pulverized powder was subjected to physicochemical analysis.

Results: *Acacia sieberiana* seeds gave an oil yield of 10.91% which was light yellow in colour. The oil had moisture content of 5.772%, viscosity of 35.02 cst, saponification value of 144.02 mgKOH / g, unsaponifiable matter of 11.42 g / Kg, iodine value of 154.12 mg / g, acid value of 19.98 mgKOH / g, and peroxide value of 2.70 mEq / Kg. The pulverised seeds showed a swelling and solubility profile that is temperature dependent with increasing swelling power and solubility index as temperature increased. Other physicochemical parameters of the seeds are gelatinization temperature – 72 °C, browning temperature: 250.6 – 251.8 °C, Charring temperature: 280.4 – 293.1 °C, pH – 5.22, foam capacity – 8 %, emulsion capacity – 68.5 %, water holding capacity – 74.74 ml, bulk density – 0.4785 g / cm³ and tapped density – 0.5495 g / cm³.

Conclusions: From the physicochemical characterization of the oil, it has very low degree of unsaturation and can be stored for a long time without getting rancid. This can make it useful in various industries and for human and animal consumption. Also, the seed flour has good physicochemical properties.

Keywords: *Acacia sieberiana*, oil, Seeds, Physicochemical, Savannah tree
Introduction

Trees and shrubs with medicinal and nutritional potentials abound in Nigeria. Several of these plants have fruits which have been identified to be nutritionally important. In recent times, the desire to conserve resources spent on importation of oil for domestic and industrial use gave renewed impetus in the search for novel sources to complement the traditional ones. Attention has therefore been focused on under-utilized local seeds for possible development and use. There are several of these under-exploited plant seeds in Nigeria.

*Acacia sieberiana* is a small to medium-sized tree. Bark grey, rough on the older trunk, peeling off the branches to reveal a yellowish layer underneath. Thorns paired at the nodes, straight, often very long (up to 15 cm). Leaves compound, large with 8-20 pairs of pinnae; leaflets pale green or yellowish-green. Flowers in axillary, globose heads, creamy-white. Fruit shiny brown, straight or slightly falcate, with more or less parallel margins, 1.3 cm thick, 9-21 cm long, 1.7-3.5 cm wide, glabrous or nearly so, indehiscent, splitting open tardily releasing about 12 seeds; seeds big - 1 cm long, hard, flat, embedded in a yellow-greenish pulp.

Taxonomy of *A. sieberiana*

Kingdom: Plantae  
Phylum: Magnoliophyta  
Class: Magnoliopsida  
Order: Fabales  
Family: Fabaceae  
Genus: *Acacia*  
Species: *sieberiana*  
Variety: *Woodii*

This classification of *Acacia sieberiana* is according to the International Legume Database Information Service.

Traditionally, *A. sieberiana* is been utilized by different communities for the treatment of various ailments including inflammation, tiredness, joint pains, bilharzia, fever, enemas and taeniasis. The bark and root extract both rich in tannins are used in treating schistosomiasis, fever, stomach ache, jaundice, ophthalmia, cough, sexual impotence, erectile dysfunction, hemorrhoids, syphilis, uterine problems and to improve lactation after child birth. The leaves are taken orally for the treatment of urinary tract disorders, tapeworm, headache, bilharzia, kidney problem, rheumatism, circulatory system disorders and as a vermifuge. While the pods are utilized as an emollient.

In developed countries the contribution of *A. sieberiana* economically is well pronounced, the gums from *A. sieberiana* are edible and used as chewing gum, in making ink, for cosmetics, and is included in turbans and head-cloths in Senegal. It is also used as an astringent and as emulsifier. The flowers are good bee forage as they are used as home for hives while the pods, leaves and shoots are used as forage for live stocks. The bark and pod are also utilized in tanning while the wood is used as firewood and charcoal. The wood is used in making furniture, tool handles and mortars as they are termite resistant. The forked branches are used in hut-building and form handles for the large bent hoe.

The seeds of *A. sieberiana* were reported to contain 4% concentration of fixed oils with a composition of 44% oleic acids and 31% palmitic acids. The bark was also reported to contain about 3.8% of condensed tannins, 4.9% and 5.1% catechin.

Abubakar et al reported that the seed is highly nutritious and contains a number of trace element within a safety limit such as manganese, calcium and iron.

Despite all the potentials of *A. sieberiana* seeds, it still remains underutilized, therefore, the present work is focused at preliminary characterization of the extracted oil as well as the physicochemical properties of the pulverized seed of *A. sieberiana*.

Materials and Methods

Study area and sample collection

The fruits were collected from uncultivated land in Jigawa state, and processed to obtain the seed which was pulverized using a laboratory blender.
for physicochemical properties and oil extraction. Jigawa state is situated in the northwestern part of Nigeria, between latitudes 11.00°N to 13.00°N and longitudes 8.00°E to 10.15°E. Kano State and Katsina State border Jigawa to the west, Bauchi State to the east and Yobe State to the northeast. To the north, Jigawa shares an international border with Zinder Region in the Republic of Niger. Most parts of Jigawa vegetation lie within the Sudan Savannah with elements of Guinea Savannah in the southern part. Total forest cover in the State is very much below the national average of 14.8%. Due to both natural and human factors, forest cover is being depleted, making the northern part of the State highly vulnerable to desert encroachment. A sieberiana is among the few species of flora that is thriving in the area.

**Determination of physicochemical properties of pulverized seeds of A. sieberiana**

**Swelling power**

The method described by Afolayan et al was used to determine the swelling power.\(^{11}\)

The powder sample (0.1 g) was weighed into a test tube and 10 ml of distilled water was added. The mixture was heated in a water bath at a temperature of 50 °C for 30 min with continuous shaking. In the end, the test tube was centrifuged at 1500 rpm for 20 min in order to facilitate the removal of the supernatant which was carefully decanted and weight of the powder paste taken. The swelling power was calculated as follows:

\[
\text{Swelling power} = \frac{\text{Weight of powder paste}}{\text{Weight of dry powder sample}}
\]

This was carried out over a temperature range of 50 °C – 95 °C.

**Solubility index**

The method described by Afolayan et al was also used to determine the solubility index.\(^{11}\) Powdered sample (0.5 g) was added to 10 ml distilled water in a test tube. This was subjected to heating in a water bath with a starting temperature of 50 °C for 30 min. It was then centrifuged at 1500 rpm for 30 min. 5 ml of the supernatant was decanted and dried to constant weight. The solubility was expressed as the percentage (%) by weight of dissolved powder from heated solution. This was carried out over a temperature range of 50 °C – 95 °C.

**Gelatinization temperature**

This was evaluated using the method of Attama et al.\(^{12}\) The powdered sample (1 g) was put in a 20 ml beaker and 10 ml of distilled water was added. The dispersion was heated on a hot plate. The gelatinization temperature was then read with a thermometer suspended in the powder slurry.

**Foam capacity**

The method of Omojola et al was used with slight modifications.\(^{13}\) Powdered sample (1 g) was homogenized in 50 ml distilled water using a vortex mixer (vortex 2 Genie set at shake 8) for 5 minutes. The homogenate was poured into a 100 ml measuring cylinder and the volume recorded after 30 s. The foam capacity was expressed as the percent increase in volume.

**Emulsion capacity**

Sample (1 g) was dispersed in 5 ml distilled water using a vortex mixer for 30 seconds. After complete dispersion, 5 ml vegetable oil (groundnut oil) was added gradually and the mixing continued for another 30 s. The suspension was centrifuged at 1600 rpm for 5 min. The volume of oil separated from the sample was read directly from the tube. Emulsion capacity is the amount of oil emulsified and held per gram of sample.

**Browning and charring temperature**

The method of Builders et al was used.\(^{14}\) Some of the powdered sample was put into a capillary tube, the browning and charring temperatures were determined using a melting point apparatus with model Electrothermal 9100.

**pH**

A 20 % w/v dispersion of the sample was shaken in water for 5 minutes and the pH was determined using a pH meter.
Water holding capacity

The method described by Omojola et al was used to determine the water holding capacity. The powder sample (5 % w/v) was dispersed in a pre-weighed centrifuge tube. The tube was agitated in a vortex mixer for 2 min. The supernatant was then discarded and the weight of the tube and hydrated sample taken. The weight was calculated and expressed as the weight of water bound by 100 g dry powder.

The bulk density

The bulk density of the powdered seed sample was determined using the method described by Narayana and Narasinga Rao with slight modification. Powder sample (50 g) was poured into a 250 cm³ calibrated measuring cylinder by means of a short – stemmed glass funnel. The volume occupied by the powder was noted to determine the bulk density.

\[
\text{Bulk density (g/cm}^3\text{)} = \frac{\text{Weight of sample}}{\text{Volume occupied}}
\]

For the tapped density determination, the cylinder was tapped continuously using a ruler until a constant volume was obtained.

Extraction of oil from A. sieberiana

The oil was extracted using hexane by adopting the method described by Association of Official Analytical Chemist, which entailed using a soxhlet extractor to extract. 200 g of the ground Acacia sieberiana seeds were packed in a muslin cloth and inserted into the soxhlet extractor and hexane was used as the extraction solvent for a period of eight hours. At the end of the period, the solvent was recovered by rotary evaporator and residual oil was oven dried at 75 °C for one hour. The extracted oil was then transferred to a desiccator and allowed to cool before analysis.

Determination of the physicochemical properties of the Oil

The acid value, saponification value, iodine value and unsaponifiable matters were determined using the procedures described by Pearson, while the procedure described by Onwuka was adopted for the determination of specific gravity. Viscosity measurement (in centistokes, cst) was performed by using an Oswald Kinematics Viscometer with an attached water bath and a thermometer.

Results and Discussion

The oil obtained from the seeds of Acacia sieberiana was found to be light yellow in colour with a yield of about 10.91%. Table 1 shows the results of the physicochemical properties of the oil while Table 2 shows the results of the physicochemical properties of the pulverized seeds. The swelling profile and solubility profile are shown in Figures 1 and 2 respectively.

Table 1: Physicochemical properties of A. sieberiana seed oil.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil content (%)</td>
<td>10.91 ± 0.16</td>
</tr>
<tr>
<td>Colour</td>
<td>Light Yellow</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>5.772 ± 0.00</td>
</tr>
<tr>
<td>Viscocity (cst)</td>
<td>35.02 ± 0.21</td>
</tr>
<tr>
<td>Saponification value (mgKOH g⁻¹)</td>
<td>144.02 ± 0.04</td>
</tr>
<tr>
<td>Unsaponifiable Matter (g kg⁻¹)</td>
<td>11.42 ± 0.26</td>
</tr>
<tr>
<td>Iodine value (mg g⁻¹)</td>
<td>154.12 ± 0.00</td>
</tr>
<tr>
<td>Acid value (mg KOH g⁻¹)</td>
<td>19.98 ± 0.14</td>
</tr>
<tr>
<td>Peroxide value (mEq kg⁻¹)</td>
<td>2.70 ± 0.00</td>
</tr>
</tbody>
</table>

±Values are means standard deviation of triplicate (n=3).

The moisture content of the seed oil is 5.772±0.0% (w/w). Moisture content is among the most vital and mostly used measurement in the processing, preservation and storage of food. The value gotten indicates that the oil has a good shelf life; hence it can be stored for a long time without spoilage.

The saponification value of the oil is very low when compared to Moringa seed oil – 155.68 mgKOH/g, Melon seed oil – 180.92 mgKOH/g and Groundnut oil - 168.30 mgKOH/g, these low values show that the lauric acid contents of the oils are also low and this is an important determinant of the suitability of the oil in soap making although the oil could still be used in
soap making since their saponification values falls within the range of some other oils used in soap making.\textsuperscript{19}

\textbf{Table 2: Physicochemical properties of} \textit{A. sieberiana} \textit{pulverized seeds.}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gelatinization temperature</td>
<td>72 °C</td>
</tr>
<tr>
<td>Foam capacity</td>
<td>8%</td>
</tr>
<tr>
<td>Browning temperature</td>
<td>250.6 – 251.8 °C</td>
</tr>
<tr>
<td>Charring temperature</td>
<td>280.4 - 293.1 °C</td>
</tr>
<tr>
<td>pH</td>
<td>5.22</td>
</tr>
<tr>
<td>Water holding capacity</td>
<td>77.74 ml</td>
</tr>
<tr>
<td>Bulk density</td>
<td>0.4785 g/cm(^3)</td>
</tr>
<tr>
<td>Tapped density</td>
<td>0.5495 g/cm(^3)</td>
</tr>
<tr>
<td>Emulsion capacity</td>
<td>68.5%</td>
</tr>
</tbody>
</table>

\textbf{Figure 1: Swelling Power of} \textit{A. sieberiana} \textit{pulverized seeds.}

The iodine value gotten for \textit{Acacia sieberiana} seed oil is quite high. It is higher than that for \textit{Adansonia digitata} seed oil (54.41±0.94 mg/g) and this reflects the presence of high percentage of unsaturated fatty acids in the seed oil as the iodine value is a measure of the degree of unsaturation of the fatty acids in an oil and could be used to quantify the amount of double bonds present in the oil which reflects the susceptibility of oil to oxidation.\textsuperscript{20} The value obtained is higher than that for moringa oil, groundnut oil and melon seed oil.\textsuperscript{19}

\textbf{Figure 2: Solubility index of} \textit{Acacia Sieberiana} \textit{pulverized seeds.}

The peroxide assay is a predominant test for oxidative rancidity in oils and fats, it is also used as a measure of the extent to which rancidity reactions have occurred during storage. Peroxide value for \textit{Acacia Sieberiana} seed oil is extremely low. Infact, it is lower than the values reported by Afolayan et al. for Melon oil, Moringa oil and Groundnut oil.\textsuperscript{19} It is also lower than that gotten for Adansonia digitata seed oil.\textsuperscript{20} The lower peroxide value of the \textit{Acacia Sieberiana} seed oil shows the fact that the oil has very high resistance to lipolytic hydrolysis and oxidative deterioration when compared with other seed oils.\textsuperscript{21} Again, the peroxide value of the oil is within the range of 0-10 mEq/kg stipulated for freshly prepared oil.\textsuperscript{22} Therefore, it is likely that storage for a long time will not lead to rancidity of the oil.

The saponification value of the oil is low when compared to Neem seed oil – 213 mgKOH/g and coconut oil - 253.2 mgKOH/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.\textsuperscript{23,25} However, the saponification value still falls within the range of that of \textit{Dennettia tripatala} fruit oil (Pepper fruit) - 159.33 mgKOH/g and African pear oil - 143.76 mgKOH/g which could be good for soap making.\textsuperscript{21,26} This indicates that the oil could also be used in soap making since its saponification value falls within the range of these oils.
The solubility and swelling profiles of the seed powder over a temperature range of 50 – 95 °C are shown in Figures 1 and 2. There was a temperature – dependent increase in both swelling and solubility. The swelling behaviour is an indication of the water absorption characteristics of a material during heating. The high solubility and swelling is a reflection of the amorphous nature of the pulp. The swelling shows a steady increase between 50 °C – 60 °C followed by a very steep increase at 60 °C and a further increase at 80 °C. Also, the solubility increases steadily between 50 °C – 95 °C. These two patterns may not exclusively rule out two sets of internal bonding forces that relax at different temperatures. A little crystalline region may also be present.

A gelatinization temperature of 72 °C was observed, which is a reflection of the type of molecular association found in the powder. This is a bit high and it was observed that the gel formed did not dissolve completely in water.

The browning and charring temperatures indicates the temperature to which a material can be heated without changing colour or charring. This is observed to be quite high for the seed pulp and quite higher than the reported values for some starches - leacina and anchomanes.13,14,27 This shows that the seed flour can even be heated to a higher temperature without changing colour or charring. This quality will make it a preferable starch in industries that use flour at higher temperatures.

The water absorption capacity of 77.74 ml in 100 g of sample is comparable with earlier results reported for ginger, tigernut, icacina trichantha, anchomanes diffomis and maize starch.12,27 This has a positive effect on the swelling capacity of the powdered sample also. The bulk and tapped densities are lower than that indicated for maize starch. The foam capacity of 8% is as been reported generally for starches.27 However, the emulsion capacity is very high and an indication of the high fat content hence showing that it may be used as an emulsifier.

Conclusions

Oil has been extracted from the seeds of A. sieberiana and some of its physicochemical properties examined. Also, the seeds have been pulverized and its physicochemical properties determined. From the physicochemical characterization of the oil, it has very low degree of unsaturation and can be stored for a long time without getting rancid. This can make it useful in various industries and for human and animal consumption. Also, the seed flour has good physicochemical properties.

Funding: No funding sources
Conflict of interest: None declared

References


