RESEARCH ARTICLE

NUTRITIONAL ASSESSMENT OF Sclerocarya birrea (Amarula) FRUIT FROM KENYA

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INTRODUCTION

Indigenous fruits play a vital role in livelihoods of many rural communities in eastern Africa, especially those living in arid and semi-arid areas by providing a wide range of products. These fruits are essential because they provide important nutrients and vitamins to the diets dominated by cereals (Nyambo et al., 2005). Many of them produce fruits during the late dry season and early wet season when stocks of cereal crops are usually low, and in addition provide a source of income to the people. Therefore, indigenous fruits can be used to mitigate poverty and spur economic growth if properly managed. Most of these fruits have been used by local communities especially during the drought or famine to overcome food shortages. Fruits from the wild are commonly used as snacks. Traditional people ate fruits between meals while looking after the animals or working in the field. Snack foods are particularly important for the children since they need to feed more frequently than adults (Chikamai et al., 1999). The inclusions of a small amount of vitamin and mineral-rich wild fruits in a staple diet make a considerable improvement in people’s nutritional status. However, these fruits are not much valued as the fruits in a staple diet make a considerable improvement in people’s nutritional status. However, these fruits are not much valued as the

Sclerocarya birrea belongs to a family of Anacardiaceae. It has been used as a source of food since time immemorial. It is a single stemmed tree with a dense spreading crown and is mainly found in wild and is dioeceously small to medium-sized tree, usually 9–12 m tall but occasionally up to 18 m, with a taproot and sturdy lateral roots extending as far as 30m with an average diameter size 120 cm. Bark is pale silvery or purplish-grey for juvenile trees and rough, dense foliage for large mature trees. Male and female flowers are borne on separate trees. The male flowers produce pollen while female flowers produce fruits for which the tree is well known. Fruits are found in clusters of up to three at the end of the twigs and always on the new growth. The fruit is plum-size yellow with a thick leathery skin and a thin layer of juice while fresh. The fresh has a taste that is tart, sweet and refreshing. Each fruit contains a hard seed which is covered by fibrous matter. The nut consists of two or three cells each with its own kernel. The main use of the tree is as source of fruit. The ripe fresh fruit is consumed after removing the skin. Kernels extracted from the fruits are also eaten raw. Fermenting the fruit at household level produces an alcoholic beverage which is either consumed directly or distilled into stronger liquor/wine. The boiled juice is used to flavour or sweeten porridge. The kernels are crushed and used to make cakes, biscuits or as a soup ingredient. The kernels are used as protein substitute and as a meat preservative which has proved to preserve meat for six or more months. It has a high oil content that is edible and also used for preservation and as a skin care ingredient in cosmetic industry. The oil is also used for softening and moisturising animal skin and leather. Livestock and wild animals feed on fruits and foliage (Hall J.B.et al., 2002). Considerable medicinal significance is attached to this tree especially from bark, root and leaves e.g. bark and leaves are used for treatment of diarrhoea, ulcers, fever while roots are used for treatment of sore eyes. The skin of the fruit is used to treat blisters caused by caterpillars. Sclerocarya birrea is probably the only indigenous fruit species in miombo woodland that has made it to the international market. Amarula wine has been commercialized in South Africa and is being sold in 63 countries worldwide while in Lusaka, Zambia it’s being produced for export with significant benefit to the rural communities (Ham, 2005).
Based on the above uses it was necessary to establish the nutritional composition of the fruits and this would enhance its value for the purpose of conservation. The chemical parameters analysed included: Ascorbic acid, determination of the percentages of moisture, ash, crude fat/oil, crude protein, crude fibre and carbohydrate. The objective of the study was to establish nutritional composition of the edible portions (pulp and kernel).

**METHODOLOGY**

**Sample collection and Preparation**

Fresh ripe fruits were collected from the field, washed and the pulp separated from the endocarp using a sterile blade. Endocarp was mechanically broken to release kernel. Ascorbic acid content and moisture content were determined immediately. The remaining fruit pulp and kernel were dried at 70°C to constant weight, ground to a fine powder with a pestle and mortar and stored at 4°C in the refrigerator to be used later for various analyses.

**Procedures**

**Moisture Content determination**

The methods of analysis of official analytical chemists (AOAC, 1990) were used for proximate analysis. Fruit pulp was removed and 5 grams of the pulp was weighed in crucibles which had been preheated at 550°C to condition. Samples were then subjected to heating at 105°C in an oven for 17 hours. The samples were allowed to cool in a desiccator before re-weighing. This continued until a constant weight was obtained. The moisture content was expressed as a percentage ratio of weight lost to original weight of a sample.

**Ash Content determination**

5.0 grams of the dry samples were weighed into a crucible which had previously been ignited and cooled before weighing. The crucible containing samples were placed in a muffle furnace that was fitted with temperature controllers and the samples ignited at 550°C and ashed for 3 hours. The samples were cooled in a desiccator and their weights were registered. In case samples were not ashed completely (indicated by black carbonaceous material), the ash was broken into finer particles with a spatula and then re-ignited for 4 more hours. Then the % ash content was calculated as:

\[
\text{Weight of Ash} \times 100 \\
\text{Weight of Dry Sample}
\]

The ash content was averaged from the data obtained in at least triplicates for each sample analysed.

**Determination of Ascorbic acid**

A standard indophenol solution was prepared by dissolving 0.05 grams of 2,6-dichlorophenolindophenol (Sodium salt) in distilled water, diluted to 100 ml and filtered. To standardize indophenol solution, 0.05 grams of pure Ascorbic acid were dissolved in 60 ml of 20% Metaphosphoric acid and diluted with water to exactly 250 ml. From this solution, 10 ml was pipetted into a 100 ml conical flask and titrated with indophenol solution until a faint pink colour persisted for more than 15 seconds. The concentration of dye was expressed as milligram of Ascorbic acid equivalent to 1 ml of the 2,6-Dichlorophenol indophenol solution. The sample was prepared by putting macerated samples into 50 ml of distilled water to which 25 ml of 20% Metaphosphoric acid was added as the stabilizing agent and this was then made to 100 ml with distilled water in a volumetric flask. 10 ml of this solution was pipetted and titrated with a standardised 2, 6-dichlorophenolindophenol solution until faint colour persisted for 15 seconds. The Ascorbic Acid (vitamin C) was calculated as mg per 100 grams.

**Determination of Crude fat**

10 grams of the sample were accurately weighed and placed into a porous cellulose thimble. The top of thimble was covered with fat free cotton to avoid losing the sample. The thimble was placed into the extraction chamber which was suspended above the flask containing 200ml petroleum ether. Soxhlet apparatus was set up and each experiment was allowed to run for 16 hours at 70°C. Once extraction period was over the thimble was removed and excess hexane recovered by distilling it off into empty soxhlet tube. The extract and remaining small volume of ether were emptied into a pre weighed beaker that was put into a water bath to evaporate all the solvent and leave the fat extract in the beaker. The difference in weight (between beaker and extract) gave the fat soluble material in the sample. Weight of extract was divided by sample weight to obtain the fat content.

**Determination of Crude Fibre**

3.0 grams of the sample was weighed and transferred into soxhlet extraction apparatus petroleum ether 40°C – 60°C. The extract was air dried and then transferred to a 1000 ml conical flask. 200 ml of 0.1275 M Sulphuric Acid was added in the following manner: 40 ml being used to disperse the sample and heated to boiling within one minute. The mixture was boiled for 30 minutes with a constant volume of the mixture being maintained. A Buchner funnel was fitted with a perforated plate by adjusting a piece of cut cotton cloth to cover the holes in the plate so as to serve as a support for a circular piece of suitable filter paper (Whatman No. 41). After 30 minutes of boiling, the contents of the flask were poured into the funnel, allowed to remain until the funnel was hot and then drained by applying suction. At the end of 30 minutes boiling period, the acid mixture was allowed to stand for 1 minute and then poured immediately into a shallow layer of hot water under gentle suction in the prepared funnel. The suction was adjusted so that the filtration of the bulk was completed within 10 minutes. The insoluble matter (residue) was washed with boiling water until the washing was free from acid and then washed back into the original flask by means of a wash bottle containing 200 ml of 0.1313 M Sodium hydroxide solution measured at ordinary temperature and brought to boiling point. It was boiled for 30 minutes with the same precautions as those used in the earlier boiling treatment, allowed to stand for one minute and then filtered immediately through Whatman No. 41 filter paper. Residue was transferred to the filter paper by means of boiling water, washed first with boiling water, then 1% HCl and finally with boiling water until free from acid. Then twice with alcohol and thrice with ether. The residue was dried at 100°C to constant weight. The sample plus ashless filter paper were incinerated at 550°C for two hours and then the weight was recorded after cooling.

**Nitrogen and Crude protein determination**

Nitrogen content, hence protein was determined using Kjeldahl method of analysis. 500mg of dry fruit samples were weighed and transferred into digestion tubes. 15ml concentrated Sulphuric acid and10g of catalyst (96%potassium sulphate, 3.5g Copper sulphate and 0.5% selenium oxide) were added to the tubes and placed in the digestion heating system pre-treated at 360°C. Complete digestion was attained when the heated solutions turned to a pale blue-green colour indicating that nitrogen has been converted to Ammonium sulphate. The tubes were allowed to cool to room temperature for 30 minutes and 70ml of distilled water was added. 50 ml of 40% (10M) NaOH was added to the digestion mixture to make it basic and ammonia from the solution was distilled into boric acid solution by putting 50 ml of 2% boric solution into a receiving flask. 3 drops of methyl red-bromocresol green indicator were added. Caution was taken to ensure the delivery tube from the distiller was placed well below the surface of the boric acid solution in the flask. After a distillation was complete, boric acid solution was titrated with 0.02M hydrochloric acid.

The percentage Nitrogen was calculated as follows:

\[
\% \text{ (w/w)} = \left( \frac{\text{Molarity of acid x 14 x 100}}{\text{weight of sample (g)}} \right) \times \text{Nitrogen (ml standard HCl acid for sample – ml of std HCl acid for blank)}
\]

To get the value of crude protein, a conversion factor of 6.25 was used i.e. % protein = % N x 6.25.
Carbohydrate content determination

This was estimated or accessed based on the assumption that fruit samples are constituted of ash, fibre, fat, protein and digestible carbohydrate. Therefore when the contents of ash, protein, fibre and fat are known for 100 grams of sample carbohydrate content is calculated by subtracting from proximate values obtained as shown below: Carbohydrate content = % 100 - sum of % proximate values (ash content + fibre content + fat content + protein content).

Determination of calorific value/internal energy

The calorific value of 0.9942g of benzoic acid was first determined as the standard. 0.5g of the samples was then weighed for analysis. The weight of the tissue paper [used to wrap the sample] and that of ignition wire were also noted. The sample was wrapped with the tissue paper and tied with ignition wire. This was placed in the sample pan and the two ends tied to the terminals. The bomb was then tightly closed and oxygen pumped in until the pressure gauge indicated 30kg/cm². The inner cylinder of the calorimeter was filled with 2100mls of distilled water and Beckmann’s thermometer of the inner cylinder was inserted. The temperature of the outer cylinder was adjusted with hot water and cold water so that the water temperatures of the inner cylinder remained within the range of 0.1°C. This was stirred for about 10 minutes after which the sample was ignited. As the temperature of the Beckmann’s thermometer of inner cylinder started to rise immediately after the combustion of the sample, initial readings were noted. Temperature for the outer cylinder was also noted and hot water continually added so that the temperature difference between the outer and inner cylinder was maintained within the range of ±0.3°C. This was done to ensure that the highest temperature of the inner cylinder was not interfered with by loss of heat to the outer cylinder. The highest temperature recorded for the inner cylinder was used for calculations.

Calorific values = \( H_2O \) equivalent+ [\( H_2O \) quantity in the inner cylinder× temp. rise of inner cylinder] - calory correction Weight of sample

Where \( H_2O \) equivalent = Calorific value of benzoic acid \( \times \) weight of benzoic acid - \( H_2O \) quantity of inner cylinder Rise in temperature of benzoic acid

Calorific value of benzoic acid = 26.46kJ at 20°C

In Kcal \( \frac{26.46}{4.2} = 6.3 \) Kcalg⁻¹

Calorific correction = (weight of tissue \( x \) its calorific value) + (weight of ignition wire \( x \) its calorific value)

Where: Calorific value of tissue paper = 3986 Cal g⁻¹
Calorific value of ignition wire = 775 Cal g⁻¹

Determination of Mineral elements

A digestion mixture of Nitric acid, Sulphuric acid and Perchloric acid in the ratio of 3:1:1was prepared and 300mg of oven dried fruit sample was weighed and put into a digestion tube.10 ml digestion mixture was added to each tube and also two reagent blank solutions as control. The mixture was placed in the digestion block and heated to 360°C for 2 hours to attain a complete oxidation. This was observed when the colour of the fumes from the tube turned white from the initial brown and the colour of the solution appeared colourless, 25 ml of distilled water was added and mixed well until no more sediment dissolved. This was allowed to cool to room temperature before it was transferred to a 50 ml volumetric flask. The mixture was be made up to 50ml mark with distilled water and mixed well. For calcium and magnesium samples 5% lanthanum was included to avoid chemical interference during atomization process. The solution was filtered and analysed using flame atomic absorption spectrophotometer (FAAS), Phosphorus analysis was carried out using colorimetric method. The method is based on the principle that phosphate ions react with ammonium molybdate to form a blue complex that has an intense absorption band at 820nm, when reduced by ascorbic acid. The complex absorbance is proportional to phosphate concentration in the original solution and was determined using UV/Visible spectrophotometer (model U.V. spectronic 21- Milton ROT CO ). Regression equation between standard concentrations and the spectrophotometer readings were used to get the phosphate concentration in the sample solutions.

RESULTS AND DISCUSSION

Nutritional Composition

i) Proximate analysis

Table 1 shows the proximate analysis where the mean percentage dry matter of pulp was 12.7 ± 0.26 and a moisture content of 87.27 ± 0.27 while the kernel dry matter was 80.98 ± 0.22 and moisture content of 19.02 ± 0.78. The results are comparable with analysis done by Akinnifesi et al. (2008) indicated that Sclerocarya birrea had a percentage dry matter of 13.7(86.3 moisture content) and 77.8 (22.2) for pulp and kernel respectively. This implies that the fruit pulp can be a good source of water and refreshment to the body. Ash content had a mean value of 3.5 ± 0.53 and 1.59 ± 0.34 for pulp and kernel respectively. This is an indication that the pulp contains mineral elements that are important to human nutrition. The mean ascorbic acid content in the edible pulp was 1.90 ± mg/g (190mg/100g). The results agree with observation by Anold et al., (1985) where mean ascorbic acid was found to be 194mg/100g in Botswana. The value obtained was higher than 160mg/100g reported by Akinnifesi et al. (2008) in Malawi but much lower than results from Eromosele et al. (1991) who found significantly large amount of ascorbic acid of 403mg/100g in Nigeria. Generally, ascorbic acid content in the fruit can vary depending on when the analysis is done after harvesting and also the level of ripening. If analysis are done immediately after harvesting the values are likely to high. Maturity of fruits at harvesting is also another factor. When the fruits have over ripened the level of ascorbic acid is low. The ascorbic acid concentration was much higher than those of oranges (30-70mg/100g) (Williamson, 1975). The recommended daily intake of ascorbic acid is 60mg (Nyambó et al., 2005) which means that about 35 grams of fruit pulp is enough to supply body’s daily requirement. Therefore Sclerocarya birrea fruit can be a better source of vitamin C than convectional fruits like oranges (57mg/100g). As presented in the Table 1, Percentage fat content was 3.4 ± 0.4 and 57.36 ± 0.95 for pulp and kernel respectively. However, the kernel results were significantly lower than value obtained by Akinnifesi et al., 2008 of 74.8% but favourably comparable with 57 % and 59.7% from the work done by Thiongo et al., 2002 and Anold et al., 1985 respectively. This indicates that kernel is a rich source of oil that can be used for cooking, cosmetic and other industrial applications. As shown in table 1, the mean protein content was 3.38± 0.14% and 30.34±0.36% for the pulp and kernel respectively. The values obtained compares well with 4.7% and 33.1% reported by Akinnifesi et al., 2008 for pulp and kernel respectively. Kernel results are also comparable with 29.5%, 30.6% and 30.4 reported by Anold et al., 1985, Busson, 1986 and Jaenicke and Thiongo, 2000 respectively. Concentration of protein in kernel revealed that it can be a good
source of protein for both human and animals. Fibre content result of 6.43±0.22 for the pulp was lower than 9.2% obtained by Houereu et al., 1980 in senegal. The values of energy content for pulp and kernel were 17.92 ± 0.27kj/g (1792kj/100g) and 30.36 ± 0.04kj/g (3036kj/100g) respectively. Pulp results were slightly higher than 1461kj/100g reported by Malaria, 1985 in Democratic Republic of Congo. Kernel also recorded a higher value than 2700kj/100g reported by national food research institute, 1972 from South Africa. The variation in results may be due to environmental conditions. Kernel can therefore be a good source of energy as the calorific values obtained were quite high. The bulk of the pulp was mainly made up of carbohydrate that could have contributed the high energy values. Presence of high amount of oil in kernel could have contributed to high calorific values. However, the pulp results differed significantly with 225kj/100g reported by Glew et al., 1997 in Burkina Faso.

The carbohydrate content of 84% was obtained by subtracting from sum of the percentage results obtained from protein, ash, fibre and fat. The above value is lower than 90.35% reported by Hasson et al. (2010). The pulp was therefore found to be rich in carbohydrate and hence a good source of energy.

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**Table 1. Summary of nutritional composition of edible portions of Sclerocarya birrea fruit**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pulp</th>
<th>Kernel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (%)</td>
<td>12.73±0.26</td>
<td>80.98±0.22</td>
</tr>
<tr>
<td>Total ash (%)</td>
<td>3.5±0.53</td>
<td>1.59±0.34</td>
</tr>
<tr>
<td>Ascorbic acid (mg/100g)</td>
<td>190±0.81</td>
<td>ND</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>3.4±0.4</td>
<td>57.36±0.95</td>
</tr>
<tr>
<td>Fibre (%)</td>
<td>6.43±0.96</td>
<td>ND</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>3.58±0.14</td>
<td>30.34±0.30</td>
</tr>
<tr>
<td>Energy (kJ/g)</td>
<td>17.92±0.27</td>
<td>30.36±0.04</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>84.1</td>
<td>ND</td>
</tr>
</tbody>
</table>

**Table 2. Concentration of mineral elements in the edible portions of Sclerocarya birrea fruit**

<table>
<thead>
<tr>
<th>Element</th>
<th>Pulp</th>
<th>Kernel</th>
<th>Detection limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>K (µg/g)</td>
<td>3220.3±3.2</td>
<td>4866.36±25.95</td>
<td>0.378</td>
</tr>
<tr>
<td>Ca (µg/g)</td>
<td>6884.58±207.39</td>
<td>4489.6±185.9</td>
<td>0.012</td>
</tr>
<tr>
<td>Fe (µg/g)</td>
<td>27.92±2.6</td>
<td>44.6±0.89</td>
<td>0.0226</td>
</tr>
<tr>
<td>Mg (µg/g)</td>
<td>1585.12±10.44</td>
<td>2537.64±19.38</td>
<td>0.048</td>
</tr>
<tr>
<td>Cu (µg/g)</td>
<td>3.2±0.75</td>
<td>17.0±0.25</td>
<td>0.0638</td>
</tr>
<tr>
<td>Zn (µg/g)</td>
<td>23.25±0.3</td>
<td>44.71±1.4</td>
<td>0.063</td>
</tr>
<tr>
<td>P (µg/g)</td>
<td>1456.34</td>
<td>1607.38±26.44</td>
<td>0.0103</td>
</tr>
</tbody>
</table>

**Conclusions and Recommendations**

The results obtained in the study show that Sclerocarya birrea fruit has a great potential as source of important nutrition. It was found to be rich in energy, minerals, fat, protein, carbohydrate and vitamin C which are important in human diet. This is an indication that the fruit can contribute to nutritional needs of the communities where it grows and also as raw materials to support local fruit processing industries. We would wish to recommend that parameters like vitamin B complex, vitamin E, water insoluble and soluble ash analysis, alkalinity of soluble ash and acid insoluble ash which were left due to short time frame to be carried out. As the pulp was found to be rich in carbohydrate it is important to analyse for invert sugars to know whether the pulp could be a good source of reducible sugars to the body. Also local fruit processing companies can be encouraged to include Sclerocarya birrea in their products making since it is rich in many ingredients required by the body. There is need for training on value addition of Sclerocarya birrea to the communities where it is found for livelihood improvement. This can be attained through establishment of cottage industries to develop products such as jam, wine, juice and edible oil among others.

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