



RESEARCH ARTICLE

NUTRITIONAL ASSESSMENT OF *Sclerocarya birrea* (Amarula) FRUIT FROM KENYA

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ABSTRACT

The aim of this study was to carry out nutrient content of *Sclerocarya birrea* (Amarula) fruits as one of the Kenyan drylands indigenous fruits with a high potential. Mature fruit samples were collected from the field in Mbeere in Eastern part of Kenya and then taken to the Forest Products laboratories for analysis. Edible portions were analysed for the nutritional composition. The analysis carried out included energy, moisture, ascorbic acid, proximate and minerals (i.e. Ca, Mg, K, Cu, P, Fe and Zn). Flame atomic absorption spectrophotometer (FAAS) was used for elemental analysis, Ultra Violet-visible spectrophotometer (UV/VIS.) for phosphorous analysis, Kjeldahl method for crude protein, bomb calorimeter for internal energy and soxhlet method of analysis for crude fat while various classical methods of analysis were employed for the other parameters. The results of analysis indicated that the kernel was rich in fat ($57.36 \pm 0.95\%$), energy ($30.36 \pm 0.04\text{kJ/g}$), protein ($30.34 \pm 0.36\%$), potassium ($486.64 \pm 2.6\text{mg}/100\text{g}$), phosphorous ($160.74 \pm 2.6\text{mg}/100\text{g}$) and calcium ($449 \pm 18.59\text{mg}/100\text{g}$) while pulp had significantly high values of ascorbic acid ($190 \pm 0.81\text{mg}/100\text{g}$), Potassium (K) ($3220.36 \pm 4.32\text{mg}/100\text{g}$), Phosphorous (P) ($145.634 \pm \text{mg}/100\text{g}$), Calcium (Ca) ($688.488 \pm 20.74\text{mg}/100\text{g}$). However iron (Fe) ($2.792 \pm 0.26\text{mg}/100\text{g}$), Magnesium (Mg) ($155.82 \pm 1.044\text{mg}/100\text{g}$), zinc ($2.33 \pm 0.03\text{mg}/100\text{g}$) and copper ($0.32 \pm 0.075\text{mg}/100\text{g}$) were present in low quantities.

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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 exotic species and there is a continuing decline in knowledge about them, especially among young people and also those living in urban areas (Nyambo *et al.*, 2005). In the recent past researchers have been diverting their attention to a whole new range of tropical trees, shrubs and herbs in the wild that produce delicious fruits and other products. The potential of these species have not been fully realized.

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 dioeciously 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 moistening 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).

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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 a 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:
$$\frac{\text{Weight of Ash} \times 100}{\text{Weight of Dry Sample}}$$

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 and 10g 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:

% (w/w) Nitrogen = $(\text{ml standard HCl acid for sample} - \text{ml of std HCL acid for blank}) \times \text{Molarity of acid} \times 14 \times 100 / \text{weight of sample (g)}$ 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^oC. 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^oC. 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 = H₂O equivalent+ [H₂O quantity in the inner cylinder× temp. rise of inner cylinder] - calory correction
Weight of sample

Where H₂O equivalent = Calorific value of benzoic acid × weight of benzoic acid - H₂O quantity of inner cylinder Rise in temperature of benzoic acid

Calorific value of benzoic acid = 26.46kj at 20^oC

$$\text{In Kcal } \frac{26.46}{4.2} = 6.3 \text{ Kcalg}^{-1}$$

Calorie 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 3:1:1 was 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^oC 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 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),

buck scientific model 220 VGF. The theory behind FAAS is that when an element is burnt it emits a specific wavelength light whose intensity is proportional to the concentration of element in the solution. The stock and standard solutions were prepared using analytical grade salts of nitrate and chloride that are of high purity. A standard curve was drawn from the absorbance readings versus concentration of standards. Using the standard curve, concentration of undiluted sample was determined and the results reported in µg/g.

$$\text{Concentration } (\mu\text{g/g}) = \text{AAS } \frac{\text{Conc. (ppm)} \times \text{vol. of sample} \times \text{dilution factor}}{\text{Wt. of sample}}$$

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 (50-70mg/100g) (Williamson, 1975). The recommended daily intake of ascorbic acid is 60mg (Nyambo *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 Thiong'o *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 Thiong'o, 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 Houerou *et al.*, 1980 in senegal. The values of energy content for pulp and kernel were 17.92 ± 0.27 kJ/g (1792kJ/100g) and 30.36 ± 0.04 kJ/g (3036kJ/100g) respectively. Pulp results were slightly higher than 1461kJ/100g reported by Malaisse, 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 Hassan *et al.* (2010). The pulp was therefore found to be rich in carbohydrate and hence a good source of energy.

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

parameter	pulp	kernel
Dry matter (%)	12.73 ± 0.26	80.98 ± 0.22
Total ash (%)	3.5 ± 0.53	1.59 ± 0.34
Ascorbic acid (mg/100g)	190 ± 0.81	ND
Fat (%)	3.4 ± 0.4	57.36 ± 0.95
Fibre (%)	6.43 ± 0.96	ND
Protein (%)	3.58 ± 0.14	30.34 ± 0.30
Energy (kJ/g)	17.92 ± 0.27	30.36 ± 0.04
Carbohydrate (%)	84.1	ND

ND=not done

ii) Elemental analysis

Table 2 shows the results of micronutrients (Zn, Fe and Cu) and macro nutrients (Ca, K, Mg and P) which were present in both pulp and kernel. The significant quantities found in both pulp and Kernel can contribute to dietary requirements.

a) Micronutrients: zinc, iron and copper

Table 2 shows the Concentration of zinc in $\mu\text{g/g}$ to be 23.25 ± 0.3 (2.325 ± 0.03 mg/g). As a trace element, the level of zinc was found to be low but in significant amount. The zinc content in the kernel compares well with the study done by Glew *et al.*, 1997 of 2.65mg/100g from Bukina Faso. However, the values were lower than 5.72mg/100g obtained by Thiong'o *et al.*, 2000. Pulp results were significantly higher than those in reported in study done in Nigeria by Emosele *et al.*, 1991 which gave a result of 0.34mg/100g. The difference in results could have been caused by factors like age of tree, soil type and phenotype. According to Mukonyi *et al.*, 2004 on phytochemical and nutritional value of *mondia whytei*, the value obtained is lower than the recommended daily intake of 15mg/day. The Zinc available can only contribute to 15% for the pulp and 30% for the kernel of the daily requirement. Table 2 shows the level of iron to be 27.92 ± 0.26 $\mu\text{g/g}$ (2.79mg/100g) and 17.0 ± 2.6 (1.7mg/100g) for pulp and kernel respectively. The value is also much lower than the recommended daily intake of 18mg/day reported by Mukonyi *et al.*, 2004. Based on the above results *Sclerocarya birrea* fruit can be supplemented with other food for provision of iron mineral. Copper was present in 3.2 ± 0.75 $\mu\text{g/g}$ (0.32mg/100g) and 17.1 ± 0.27 $\mu\text{g/g}$ (1.71mg/100g) for pulp and kernel respectively. The recommended daily intake is 2mg/day (Mukonyi *et al.*, 2004). The level was low for the pulp but present in significant amount for the case of kernel.

b) Macronutrients: Calcium, Magnesium, Potassium and Phosphorus

As shown in Table 2, the level of calcium was 6884 ± 20.74 $\mu\text{g/g}$ (or 688.46mg \pm 2.07/100g) for pulp and 4489.60 (449.0mg \pm 100 g) for kernel. The dietary requirements for calcium are 800-1200mg/day (shells and young, 1987). Pulp registered a higher level as compared to kernel but slightly lower than what is recommended as daily intake. The available calcium in the edible portions can meet about 90% of the daily requirement Magnesium was present in high concentration of 1588.12 $\mu\text{g/g}$ (158.8mg/100g) and 2537.64 \pm 19.38 $\mu\text{g/g}$ (253.76 \pm 1.94mg/100g) for pulp and kernel respectively. The amount in pulp was slightly higher than the one reported by Akinnifesi *et al.*, 2008 of 100mg/100g in Kenya but lower than (310mg/100g) reported by Glew *et al.*, 1997. Recommended daily intake for magnesium is 280-350mg/day according to Nyambo *et al.*, 2005. The amount of potassium in fruit samples was 32203.6 \pm 43.2 $\mu\text{g/g}$ (3220.36mg/100g) and 4886.36 \pm 25.9 $\mu\text{g/g}$ (488.4mg/100g) for pulp and kernel respectively as indicated in the table. Potassium was the most abundant element in the fruit. This value was significantly higher than 600 mg/100g for kernel and 2400mg/100g for pulp reported by Akinnifesi *et al.*, 2008. This difference in results could have been attributed by different soil, maturity of the fruits at the time of harvest and perhaps provenance. The recommended daily intake is 2000mg/day reported by Nyambo *et al.*, 2005. Therefore the fruit could contribute significantly to dietary requirement for human. The concentration of phosphorus was 1456.34 \pm 0.43 $\mu\text{g/g}$ (145.63mg/100g) and 1607.36 \pm 6.44 $\mu\text{g/g}$ (160.74 mg/100g) for pulp and kernel respectively. The values were slightly lower than 200mg/100g for pulp and 900mg/100g for the kernel reported by Akinnifesi *et al.*, (2008). The recommended daily intake of phosphorus is 800mg/day (Nyambo *et al.*, 2005).

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

Parameter	Pulp	Kernel	Detection limit
K ($\mu\text{g/g}$)	32203.6 ± 43.2	4866.36 ± 25.95	0.378
Ca ($\mu\text{g/g}$)	6884.58 ± 207.39	4489.6 ± 185.9	0.012
Fe ($\mu\text{g/g}$)	27.92 ± 2.6	44.62 ± 0.89	0.0226
Mg ($\mu\text{g/g}$)	1585.12 ± 10.44	2537.64 ± 19.38	0.048
Cu ($\mu\text{g/g}$)	3.2 ± 0.75	17.0 ± 0.25	0.0638
Zn ($\mu\text{g/g}$)	23.25 ± 0.3	44.71 ± 1.4	0.063
P ($\mu\text{g/g}$)	1456.34	1607.38 ± 26.44	0.0103

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, 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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REFERENCES

- A.O.A.C. (1990): 15th Official methods of Association of Official Analytical Chemists, Washington D.C. USA. Pp. 807-928.
- Akinnifesi F.K, Leaky R.R.B., Ajayi O.C, Sileshi, G, Z.Tchoundjeu, Matakaala P. and Kwesigga F.R; (2008): Indigenous Fruit Trees in the Tropics, CAB International., pp 210-212 & pp288-300.
- Arnold, T.H., Wells, M.J. and Wehmeyer, A.S. (1985): Khoisan food plants: taxa with Potential for future economic exploitation. In: Plants for arid lands.
- Aurand L.W, Woods A.E and Marion R.Van Nostran Reinhold (1987): Food Composition and Analysis, PP 19-34.
- Chikamai B.N., (1997): Laboratory Manual for Gum and Resins, pp. 1-5.
- Chikamai B.N., Ng'ethe R.K., and S.S Mbiru (1999): Vegetation Resources And Opportunities For The Development Of Alternative Livelihoods In Dry Lands, 1st edition, Foundation press, PP 69-71.
- Eremosele *et al.* (1991): Chemical composition of selected indigenous fruits of Africa.
- Glew R.H. *et al.* (1997): Amino acid, fatty acid, and mineral composition of 24 indigenous plants of Bukina Faso.
- Hall J.B., (2002): *Sclerocarya birrea* (A.Rich.) Hochst. [Online]. Record from Protabase.Oyen LPA and Lemmens RHMJ, editors. PROTA (Plant Resources of Tropical Africa/Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. Available at: <http://database.prota.org/search.htm>. (Accessed 29th August 2012).
- Hassan *et al* (2010): nutritional and antinutritional composition of *Sclerocarya birrea* fruit juice. <http://ajol.info/index.php/njbas/index/issn/0794-5698> (accessed on 29th August 2012).
- Kenji G.M & Karanja P.N., (2009): 1st draft edition, analysis of foods practical manual, JKUAT, pp. 33-45.
- Malaisse, F. & Parent, G. (1985): Edible wild vegetable products in the Zambebian woodlands area: a nutritional and ecological approach. Ecology and nutrition journal 18, pp 42-82.
- Maundu P. (1999): Traditional food plants of Kenya PP 205- 206.
- Mukonyi k.w and Lwande W. (2004): Report on Phytochemical and nutritional value of *Mondia whytei*. A paper presented in 2nd KEFRI scientific conference pg. 153-164.
- Muok, B.O and Owuor, B., (2005): The under Utilized Resource – Propagation, establishment and Management of *Sclerocarya birrea* pp 1-3 (Unpublished) <http://pages.bangor.ac.uk/~afs032/project.html> (accessed on 19th July 2011)
- Nyambo A., Nyamora A., Ruffo C.K., and Tengnäs B. (2005): Technical handbook on fruits and nuts. Species with potential for Tanzania; world Agroforestry pp 139-145.
- Ondachi P. W. (2001): Report on nutritional studies of indigenous fruit trees 2001 pp. 8-13.
- Skoog A.D. (1985): Principles of instrumental analysis 3rd Edition, The Dryden press, pp. 279-281.
- Thiong'o, M.K., King'ori, S., Jaenicke, H., Mathooko, F.M., Kenji, G.M., and Njoroge, S.M., (2000): Characterization of lipids in Kentan marula (*Sclerocarya birrea*) seed oil from different provenances. Report of a collaborative ICRAF/ JKUAT project, ICRAF, Nairobi, Kenya, 41 pp.
- Wickens, G.E., Goodin, J.R., & Field, D.V. (Eds.). Proceedings of the International Conference on Economic Plants for Arid Lands, 23-27 July, 1984, Royal Botanical Gardens, Kew.
