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Nutrient Content of Bamboo Shoots from Selected Species in Kenya

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Abstract: Information on nutrient composition of bamboo shoots is scanty despite being used as vegetables in some parts of Kenya. In this study, the nutrient content of shoots from selected exotic bamboo species (*Dendrocalamus giganteus*, *Dendrocalamus membranaceus*, *Dendrocalamus asper, Oxytenanthera abyssinica* and *Bambusa vulgaris)* growing in various agro-climatic regions in Kenya were determined. The study aimed at determining the nutritional potential of the bamboo shoots in order to evaluate their suitability for enhancing food and nutrition security. This will in turn enhance the value of bamboo for conservation, utilization, contribution to economic development and rural poverty reduction. Samples were analysed for proximate composition, minerals, vitamin, and calorific values using standard procedures. Moisture levels ranged from 89.9% to 92.1%. On dry weight basis, crude fibre ranged between 17.6% and 34.8%, protein 18.9% and 38.7%, ash 9.3% to 12.8%. On wet weight basis, vitamin C ranged between 2.03 to 4.17mg/100g, riboflavin 0.02mg/100g and 0.05/100g, niacin (B3) 0.19mg/100 and 0.08mg/100g. On wet weight basis Magnesium content ranged between 0.09mg/100g and 3.31mg/100g, Aluminium 28.27mg/100g and 47.34mg/100, Calcium 2.33mg/100g and 31.25mg/100, Iron 0.83mg/100g and 5.31mg/100, Copper 0.15/100 and 0.19mg/100g, Zinc 0.10mg/100g and 1.95mg/100, Sodium 4.49mg/100g and 9.51mg/100g and Potassium 1.77mg/100g and 236.73mg/100g. Calorific values on dry weight basis ranged from 393.99Kcal/100g to 464.86Kcal/100g. The findings on the nutritional content in terms of fibre, protein and minerals make bamboo shoots a potential meal for consideration in Kenyan households.

Keywords: Bamboo, Shoots, Nutrients, Kenya, Utilization Potential

1. Introduction

Bamboo is a form of grass belonging to the family *Poaceae* and sub-family Bambusoideae. There are over 1640 species of bamboo, widely distributed in the tropical and sub-tropical regions of the world [1]. These plants are documented to be among the fastest growing plants on the planet [2]. Bamboos are an integral part of Kenya's forests ecosystem covering an estimated area of 130, 000 ha [3, 4]. Kenya hosts one indigenous species: *Oldeania alpina (syn. Yushania alpina and Arundinaria alpina),* also known as the African Highland Bamboo. It is found in the Aberdare range, Mount Elgon, Mount Kenya, Mau escarpment and Cherang'any Hills between altitudinal ranges of 2300 – 3500 M above mean sea level [4]. A number of the exotic species belonging to the genus *Bambusa, Dendrocalamas, Gigantochloa, Oxytenanthera, Phyllostachys* amongst others have been introduced in the central and western regions of Kenya [5-7].

Bamboos plants have over 10,000 known uses [8] and utilities ranging from sustenance use to high end industrial composite products. Bamboo shoots are consumed as a vegetable by numerous communities in Asia, Africa and Latin America. Of the 1640 bamboo species globally, about 200-500 species have shoots of edible quality and only less than 100 species have commonly used edible shoots [9]. They are one of the most important globally traded

commodities, which accounts for 19 per cent of the bamboo and rattan commodities trade which is valued at USD 320 billion [10].

The bamboo plant which is evergreen, comprises of aerial stems referred to as culms, which arise from a network of rhizome systems. An emerged young culm is what is called a bamboo shoot. It is comprised of short vertical nodes and internodes tightly clasped with overlapping sheaths from which edible parts are harvested [11]. A bamboo shoot will grow into a bamboo culm within 3-4 months if it is not harvested. These typically emerge during the wet season and are harvested after attainment of 20-30cm in height. Shoots when exposed to light can be bitter as cynogenic glycosides are formed in the shoot [11].

Bamboo shoots are important food sources for numerous communities in South-East Asia and in Africa. In Kenya and Uganda, a local delicacy of bamboo shoots is made by communities around Mount Elgon [7]. In Uganda dried and smoked bamboo shoots, locally called *malewa* [12, 13] are widely traded and consumed as a regular meal. The shoots are prepared together with groundnut sauce as a daily meal. In Asian countries these shoots are prepared and consumed in different forms such as fresh, fermented, pickled, chips, snacks among many forms [14, 15]. For a number of people, bamboos are a significant source of food security and nutrition.

Bamboo shoots have immense potential for usage as health foods due to their high useful protein, carbohydrates, amino acids, low fat, dietary fibres and important minerals and vitamins among others [11, 15-19]. The shoots have been found to have additional health benefits, such as reducing fever and maintaining water balance in the body [20]. They have also been found to lower blood cholesterol and improve bowel movement [21, 22, 11]. Bamboo shoots with their high nutritive value, bio-active compounds coupled with fast growing nature provide immense potential to enhance food security [21, 23]. Cancer is ranked third amongst illnesses causing deaths in Kenya after infectious and cardiovascular diseases [24, 25]. This is attributed to increased life expectancy, unhealthy lifestyles and unhealthy dietary habits (among others) [25]. The prevalence of hypertension in the general population in Kenya, stands at 24% [26]. Bamboo shoots are reported to contain substantial amounts of minerals especially potassium, dietary fibre, antioxidants and low fat which are essential in controlling hypertension and the spread of cancer [11].

Bamboo shoots are also one of the important globally traded commodities and the international markets are expanding providing opportunities for exports, creating rural employment and directly contributing to smallholder livelihood development and poverty alleviation [11, 10]. The shoots are harvested annually at the onset of the rains. The initial shoots are the ones harvested and those that emerge towards the end of the shooting period are selected and left to develop into culms and thus ensuring sustainable management of bamboo [27].

The combination of the above facts on bamboo shoots has necessitated this assessment to determine the nutritional content of bamboo shoots in Kenya and to evaluate its suitability for enhancing food and nutrition security. This will enhance their importance for the purposes of conservation and utilization, contribution to economic development, rural poverty reduction and environmental management coupled with climate change mitigation and adaptation benefits. This study has profiled the nutrient content of shoots from selected bamboo species as an alternative source of vegetables.

2. Methodology

2.1. Sample Acquisition and Preparation

Fresh bamboo shoots of *Dendrocalamus giganteus*, *Dendrocalamus membranaceus, Dendrocalamus asper, Oxytenanthera abyssinica and Bambusa vulgaris* were collected from Nyahera (Kisumu County), Nguriunditu (Kiambu County) and Karura (Nairobi County). The shoots were randomly sampled from selected farms with four (4) shoots of each of the species being harvested. Shoots of height 10-15 cm (about two to three weeks old) were selected, harvested with a sharp knife and temporarily stored in a cool box while in the field. Under laboratory conditions, the outer scales or sheath of the shoot samples were peeled off and the fibrous or hard lower portions of the shoot trimmed off with a knife. The remaining inner soft part which is usually the edible part was prepared for analysis.

2.2. Proximate and Mineral Analysis

2.2.1. Moisture Content

The moisture level of the samples was determined as described by the methods of Association of Official Analytical Chemists (AOAC) Method 930.04 (1995). Macerated sample (5.0 g) was oven-dried at 105°C to a constant weight. This was carried out in triplicates and the mean moisture level calculated from the ratio of lost masses to initial sample weight expressed as a percentage.

2.2.2. Fibre Content

Fibre content of the samples was determined from a protocol described by AOAC [28]. About 2.0 g of each bamboo species was transferred into 600mL Buchner flask, 200mL of 0.127M sulphuric acid added and the Buchner flask connected to a fibre digestion apparatus. The content was boiled for 30 minutes, allowed to cool and later on filtered using a Buch flask. 200ml solution of 1.25% NaOH was added and boiled for 30 min. The digest was filtered, washed in three batches of 50ml distilled water, 50ml ethanol and 50ml petroleum ether. The residue was ashed at 600°C for 30 min and allowed to cool in a desiccator. The fibre content was calculated as a percentage of the lost weight during incineration to the initial sample weight expressed as a percentage [29].

2.2.3. Crude Fat

The samples' crude fat content was determined using the Soxhlet's extraction method as described by [29]. Sample

weighing 5g was transferred into a thimble and petroleum ether added to extract fat. The extraction was carried out in a Soxhlet apparatus which ran for 8 hours. The solvent was removed using a rotary evaporator and the extract dried in an oven for 10 minutes at 80°C. The content was allowed to cool in a desiccator. The amount of fat extracted was expressed as a percentage of the initial weight of the sample.

2.2.4. Nitrogen and Crude Protein

The amount of nitrogen and crude protein was analysed using the semi-micro Kjedahl method [29]. Sample weighing 1.0g was transferred into a digestion flask. A catalyst mixture of potassium sulphate (5.0g), Copper sulphate (0.25g) and concentrated Sulphuric acid (15ml) were added and rotated till the acid soaked the sample. The mixture was heated with gradual increase in temperature up to 350°C when the colour of the solution changed from black – brown –blue. The blue solution was further heated for an extra 30-60min and allowed to cool to 25°C. The digest was put into a 100ml volumetric flask and filled up to the mark using distilled water. 10ml of the diluted digest was pippeted into a different flask and 15ml of 40% NaOH added. The ammonia liberated was trapped with 50ml solution of 2% boric acid in a receiver flask with bromophenol blue indicator. The resulting solution was titrated against 0.02M hydrochloric acid and the percentage nitrogen content calculated as shown in equation [29]. Protein content of the samples was computed by multiplying the percent nitrogen content by a conversion factor of 6.25 [30].

$$\%\left(\frac{w}{w}\right)\text{Nitrogen} = \frac{(\text{ml HCl for sample} - \text{ml of standard HCl for blank}) \times \text{Molarity} \times 14 \times 100}{\text{Weight of sample (g)}}$$

2.2.5. Ash Content

Samples' ash content was determined using method 930.05 of AOAC (1995) where 5.0 g of the sample was transferred in a crucible and incinerated in a muffle furnace at 550°C for 6 hours when the ash turned grey. The crucible was allowed to cool in a desiccator at room temperature. The weight of the ash was determined and expressed as a percent to the sample weight [30].

2.2.6. Carbohydrate Content

Total carbohydrate content was expressed as the weight of the sample less the sum of moisture content, fat, ash, crude fibre and protein expressed as a percentage [31].

2.2.7. Mineral Composition

Levels of minerals present in the samples were determined by digesting 2.0g of the sample with 10ml nitric acid. The resulting digest was diluted with 50 ml distilled water and filtered. The concentration of selected minerals was determined using Atomic Absorption Spectrophotometer (Agilent Model: Spectra 55). Varying concentrations of the standard mineral solutions for each element were prepared and used to make calibration curves. An aliquot of each sample solution was aspirated and the concentrations obtained from the AAS [31] method 985.01).

2.3. Analysis of Vitamins

2.3.1. Riboflavin and Nicotinic Acid

Chromatographic separation of vitamins was realized by a Shimadzu prominence HPLC system using isocratic elution mode on a C-18 column (150 mm × 4.6 mm × 5 μm) integrated with a C-18 Guard column (5 mm × 2.1 mm × 5 µm) with oven temperature set at 30°C. The levels of riboflavin, nicotinic acid (niacin/B3) and thiamine in the samples were determined using methods described by Hossain *et al* [32]. For the analysis of riboflavin, the following conditions were set; mobile phase 'A' was composed of buffered deionised water (25mM potassium dihydrogen phosphate), while mobile phase 'B' was 100% acetonitrile. The LC separation mode was isocratic, with 70% of mobile phase A. Mobile phase flow-rate was set at 1ml/min. Fluorescence detector excitation and emission wavelengths were set at 370 nm and 450 nm respectively. Total chromatographic run time was 15 min for every sample analysed. In nicotinic acid (Niacin/B3) analysis**,** the conditions were as for the riboflavin apart from the UV detector wavelength that was set at 254 nm and a total chromatographic run time of six minutes. Three grams of samples were macerated in a pestle and mortar to form slurry, transferred into 20 ml volumetric flask and topped up to the mark with deionised water. Vitamins were extracted by ultra-sonication method for 20 minutes. The extracts were filtered using Whatman filter paper No. 1 followed by vacuum filtration using 0.45µm filters.

2.3.2. Thiamine

Thiamine was analysed using the method described by Zhu *et al* [33]. Thiamine was converted to a fluorescent thiochrome by dissolving 0.1g of $K_3Fe(CN)_6$ in a 100ml volumetric flask using de-ionized water to make 1000ppm solution. 5ml of 5M NaOH and 0.2 ml of 1% Potassium Ferro cyanide were put into a clean 100ml volumetric flask. 10 ml of standard i.e., 0.1% thiamine was then added and topped up to the mark using mobile phase to make 100 ppm solution. Working standards were prepared by appropriately diluting the stock solution with the mobile phase. Fluorescence detector was set at 385nm for excitation spectrum and 433nm for emission spectrum. It took a total of 10 min to run each sample.

2.3.3. Vitamin C

Vitamin C levels were determined using titrimetric method as described by Trang [34]. Macerated samples were mixed with 50 ml of distilled water, 25 ml of 20% metaphosphoric acid added as a stabilizing agent and made to 100ml with distilled water in a volumetric flask. 10ml of this solution was pipetted and titrated with a standardized 2, 6-dichrolophenolindophenol solution. Vitamin C levels were calculated from the titre values.

2.4. Determination of Calorific Value

Calorific values of the samples (1.0g each) were determined using a Bomb Calorimeter (Model Yoshinda 1013J,) as previously described by Kobayashi *et al* [35].

2.5. Data Analysis

Data analysis was done using Excel spread sheet and Statistical Package for the Social Sciences (SPSS). R software was used to determine the significant difference between the samples (P<0.05).

3. Results and Discussion

3.1. Proximate Composition

Results of proximate analysis for five (5) bamboo species is shown in Table 1. The moisture content of the shoots ranged from 89.91% to 92.21% with *Dendrocalamus giganteus* having the highest level of moisture content at 92.21%. The results are comparable with values obtained by Karanja *et al* which reported *B. vulgaris* at 91.4% and D giganteus at 91.2% moisture content respectively [36].

Table 1. *Mean percentage proximate composition of bamboo shoots.*

Parameter	*D. giganteus*	*D. membranaceus*	*D. asper*	*O. abyssinica*	*B. vulgaris*
Moisture content	92.2±0.87^{a}	91.8±0.4^{a}	89.9±1.2^{a}	91.4±0.3^{a}	90.9±0.1^{a}
Crude Fat	2.5±0.2^{a}	2.6±0.3^{a}	1.2±0.2^{b}	2.2±0.3^{a}	2.8±0.3^{a}
Crude Protein	29.8±2.8^{b}	18.9±1.8^{c}	19.4±0.0^{c}	28.3±0.1^{b}	38.7±0.1^{a}
Ash content	12.8±0.4^{b}	9.8±0.1^{a}	9.8±0.1^{a}	9.9±0.1^{a}	9.3±0.1^{a}
Fibre content	22.6±1.4^{a}	23.4±0.2^{a}	34.8±0.0^{b}	17.6±0.1^{c}	18.9±2.4^{c}
Carbohydrate content	23.8±0.9^{a}	21.3±1.6^{b}	29.0±0.1^{c}	33.6±0.6^{d}	17.6±1.4^{e}

Values are Mean±SD; n=3. Means with the same superscript are not significantly different from each other (P<0.05).

The fibre content in the bamboo shoots was found to range between 13.3% and 34.83% with *D. membranaceus* recording the lowest value. This is consistent by values recorded by Bhatt BP *et al* which ranged between 23.1 to 35.5% dry weight basis (dwb) [37]. 100g of fresh bamboo shoots has potential of contributing 2.2 mg (11%) of roughage/dietary fibre [19] required daily which is important in controlling constipation as well as decreasing bad (LDL) cholesterol levels. Fat content in bamboo shoots is very low. The crude fat content in the dry weight samples ranged from 1.6 - 2.8% (0.16-0.26% wet weight) with *D. asper* samples recording the lowest value. Bhat *et al* and Satya *et al* reported fat content in bamboo shoots of 0.3 and 0.6 - 1.0% respectively from the fresh weight [37, 38].

The protein content in *Dendrocalamus membranaceus* was lowest at 18.9% dwb and highest in *Bambusa vulgaris* at 38.68% dwb. Some studies have reported the protein value to be high in the range 21.1–25.8% on a dry weight basis [39, 40]. The protein values *D. asper* (19.36%) is consistent with studies by Kumbhare and Bhargava [39] and on *D. asper* species of shoots which reported values ranging from 19.2 to 25.8% dwb. Bamboo shoots has potential for contributing proteins to household diets with 100gm of fresh shoots holding about 2.6g protein is able to contribute 5% of daily required levels of protein [19].

Ash is part of the material that remains after incineration at 550°C. The results indicate that *D. giganteus* has higher (12.84% dwb) ash content than the other four bamboo species. There was however no significant difference between ash content in *D. membranaceus*, *D. asper* and *O. abyssinica*.

The levels of carbohydrates in the shoots were 17.6 - 33.6% (*B. vulgaris* and *O. abyssinica* recording the lowest and highest values respectively) that were significantly higher than those reported in other studies. Lower carbohydrate values of 6.5, 4.9, 5.5 and 5.4% were reported in *B. vulgaris, D. asper, D. giganteus* and *D. membranaceus* respectively [11]. In addition, Nongdam and Tikendra reported carbohydrate values of 3.4 and 2.9% for *B. vulgaris* and *D. asper* respectively [16].

3.2. Vitamin Content

The results revealed that all the shoots analysed had significant amount of Vitamin C as indicated in Table 2 below. Vitamin C content ranged between 2.03 – 4.17mg/100g with *Dendrocalamus giganteus* having highest levels (4.17mg/100g) than all other species while *Bambusa vulgaris* registered the lowest content of 2.03mg/100g. Other studies have reported Vitamin C values in the shoots of B. vulgaris, D. asper, D. giganteus and *D. membranaceus* to be 4.80, 3.20, 3.28 and 2.43mg/100g respectively [11]. Ogbede *et al* reported a mean vitamin C level in cabbages, one of the common vegetables consumed in Kenyan households, as 56.37mg/100g [41] which is significantly higher than what is reported in this study.

Table 2. *Mean levels (mg/100g) of vitamin content of the bamboo shoots {wet weight basis (wwb)}.*

Vitamins	*D. giganteus*	*D. membranaceus*	*D. asper*	*O. abyssinica*	*B. vulgaris*
Nicotinic acid	0.19±0.06^{c}	0.08±0.01^{b}	0.1±0.01^{b}	BDL^{a}	0.38±0.14^{d}
Riboflavin	0.03±0.01^{a}	0.03±0.01^{a}	0.45±0.07^{b}	0.02±0.01^{a}	0.03±0.00^{a}
Thiamine	BDL	BDL	BDL	BDL	BDL
Vitamin C	4.17±0.94^{d}	2.97±0.13^{bc}	2.71±0.42^{b}	3.87±0.42^{c}	2.03±0.09^{a}

BDL: Below Detectable Level; Values are Mean±SD; n=3. Means with the same superscript in a row are not significantly different from each other (p>0.05).

Riboflavin content was generally low in all the samples with *D. asper* registering the highest levels of 0.05/100g wwb and *O. abyssinica* with the least (0.02mg/100g wwb). The levels of Niacin (B3) in the shoots were highest in *B. vulgaris* at 0.38mg/100g wwb while in *O. abyssinica* was below the detection limit of the equipment (of 0.01mg/litre). Bamboo shoots have been shown to contain these useful vitamin B-complex group of vitamins and can contribute to daily required levels of 4% (Niacin), 5% (Riboflavin) and 12% (Thiamine) according to USDA report of 2006. These vitamins are essential for optimum cellular enzymatic and metabolic functions.

3.3. Mineral Composition

The Magnesium content in *D. asper* (3.31mg/100g) was the highest while *O. abyssinica* was lowest at 0.09mg/100g (Table 3). Higher values ranging between 5.38-140mg/100g were however recorded by Bhargava *et al* and Bhatt *et al* [42, 43, 37]. Aluminium content was highest in *D. membranaceus* (39.25mg/100g). The calcium content in the bamboo shoots ranged between 2.33-31.25mg/100g. Reports by Kumbhare and Bhargava [39] indicated values ranging 30 - 400mg/100g. Iron was highest in *B. vulgaris* (5.31mg/100g) and lowest in *D. giganteus* (0.83mg/100g). These values are higher than values from other studies [18, 44] which recorded Iron content in different bamboo shoots ranging 0.1-3.37/100mg.

Copper in the bamboo ranged between 0.15mg/100g – 0.19mg/100g with none being detected in *B. vulgaris*. USDA report of 2006 showed that 0.19mg/100g of fresh bamboo shoots is able to contribute to 21% of the daily required levels of copper. Copper is useful in the production of red blood cells. Zinc was highest in *D. membranaceus* (1.95mg/100g) and lowest in *B. vulgaris* (0.1mg/100g). Studies by Nirmala *et al* of five species of bamboo shoots showed Zinc values ranging between 0.57 – 1.01mg/100g [45].

Table 3. *Mean levels (mg/100g) of minerals of bamboo shoots (wet weight basis).*

Mineral	*D. giganteus*	*D. membranaceus*	*D. asper*	*O. abyssinica*	*B. vulgaris*
Magnesium	0.20 ±0.04^{b}	0.46±0.12^{c}	3.31±0.20^{d}	0.09±0.03^{a}	0.12±0.04^{a}
Aluminium	28.27±2.13^{a}	39.25±0.54^{c}	33.32±2.18^{b}	47.34±0.74^{d}	30.93±1.85^{a}
Calcium	31.25±0.92^{e}	7.79±0.20^{c}	10.43±1.37^{d}	BDL^{a}	2.33±0.41^{b}
Iron	0.83±0.02^{a}	3.01±0.38^{c}	2.24±0.31^{b}	1.76±0.19^{b}	5.31±0.10^{e}
Copper	0.16±0.01^{b}	0.19±0.06^{b}	0.15±0.05^{b}	1.66±0.05^{c}	BDL^{a}
Lead	0.16±0.02^{b}	0.30±0.09^{b}	0.24±0.07^{b}	BDL^{a}	BDL^{a}
Zinc	1.29±0.08^{a}	1.95±0.14^{a}	1.32±0.09^{a}	1.58±0.28^{a}	0.10±0.03^{a}
Sodium	5.40±0.12^{a}	8.4±0.7^{b}	5.08±0.55^{a}	4.49±0.45^{a}	9.51±0.17^{c}
Pottasium	5.06±0.61^{b}	4.32±0.42^{b}	1.77±0.71^{a}	236.73±1.76^{d}	7.17±0.16^{c}

BDL: Below Detectable Level; Values are Mean±SD; n=3. Means with the same superscript in a row are not significantly different from each other (p>0.05).

The Sodium content in the bamboo shoots ranged between 5.08 – 9.51 mg/100g, with B. vulgaris with the highest value and *O. abyssinica* having the lowest value at 4.49mg/100g. The Potassium content in the bamboo shoots was low except for *O. abyssinica* which registered value of 236.7mg/100g which is consistent with the findings of Chongtham *et al* ranging from 232 to 576mg/100g [23].

The Calcium, Iron, Copper and Zinc content is comparable to that of cabbage (*Brassica oleracae*) at 28.9mg/100g, 2.15mg/100g, 0.05mg/100g and 2.11mg/100g respectively [41], a vegetable that is not so leafy and is commonly eaten in most households. However, the Sodium and Potassium content for cabbage is higher at 176mg/100g and 678mg/100g [41] respectively.

3.4. Calorific Value

Bamboo shoots are generally low in calories. The results in Table 4 shows that *D. asper* and *O. abyssinica* had the highest levels at 17.46 kJ/g and 19.46kJ/g respectively with *D. membranaceus* registered the lowest content of 16.49 kJ/gram. The calorific values of the studied bamboo shoots are consistent with those reported in other countries. For instance, the values of *D. giganteus* at 16.77kJ/g (402.4 kcal/100g) are comparable with values reported at 16.9 kJ/g (403.92 kcal/100g) for *D. giganteus* [37].

Table 4. *Calorific value of bamboo shoots (Dry weight basis).*

Parameter	Species/Calorific value (kJ/gram)				
	D. giganteus	*D. membranaceus*	*D. asper*	*O. abyssinica*	*B. vulgaris*
Calorific value	16.77±0.57^{b}	16.49±0.13^{a}	17.46±0.36^{c}	19.46±0.02^{d}	19.26±0.11^{e}

Values are Mean±SD; n=3. Means with the same superscript are not significantly different from each other (P<0.05).

4. Conclusion

Bamboo shoots are already a local dish for communities living around Mount Elgon in Kenya. However, bamboo shoots are not consumed by majority of the population in Kenya due to lack of knowledge on its nutrition and health benefits. The nutritional assessment results of bamboo shoots in Kenya shows that they are rich in fibre, protein and low in fat. Moreover, the findings illustrate a considerable beneficial

nutritional content in terms of energy, vitamins and minerals. Bamboo shoots has huge prospects to contribute to food and nutritional security for the Kenyan population and to a number of African countries where bamboos are an integral part of their forest ecosystems and the prevalence of food and nutritional insecurity. This necessitates widespread awareness and promotion of bamboo shoots as a healthy nutritious food and to remove the stigma associated with eating bamboo shoots. Moreover, this would open up new enterprise and market avenues of small holder farmers who started bamboo cultivation in different parts of Kenya. With new enterprises anticipated to open up, guidelines for storage, transportation and processing of bamboo shoots need to be developed. This will ensure quality production and processing of bamboo shoots. Consistent efforts in market promotion, technology transfer for value addition, suitable enabling environment coupled with widespread awareness will be needed to mainstream bamboo shoot as an alternative health and nutritional vegetable in Kenya. This will not only enhance the food and nutritional index, but also aid in socio-economic development. It will also meet the targets set in Kenya's development blueprint of the Big Four Agenda which comprises food security. Noting that the shoots were collected from different agro-ecological regions, it would be necessary to undertake further investigations to determine the effect of soil and climatic conditions on the nutrient levels. The five species assessed are amongst the 22 species introduced in Kenya from Asia [6]. Nutritional assessment of the remaining bamboo species should be done to ensure comprehensive information is available.

Conflict of Interest

The authors declare that they have no competing interests.

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