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Full Length Research Paper

Sweet potatoes in Cameroon: Nutritional profile of leaves and their potential new use in local foods

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Sweet potato (*Ipomoea batatas*) leaves especially the beta-carotene fortified varieties are rich in functional macro - and micronutrients such as dietary fibres, antioxidants and other micronutrients deficient in the predominantly starchy staples of most nutritionally vulnerable Africans. In this study, the nutrient content of young leaves and succulent green stems of local and exotic varieties were evaluated using standard analytical procedures. Dry matter content was lowest and highest in young leaves of the exotic Jewel 56638 and Mbouda local varieties, respectively. Young leaf crude protein content was 15.1% in the variety Jonathan and 27.1% in the Santchou local variety. Crude fibre and ash content were higher in the young leaves and stems of the exotic varieties. Leaf total carotenoid content varied significantly across varieties. The leaves were found to soften *Gnetum africanum* vegetable sauce giving it an acceptable appearance, texture, flavour and taste. About 80% of respondents on a survey were willing to readily use sweet potato leaves to substitute for *Talinum triangulare* (waterleaf) in the preparation of *G. africanum* sauce during periods of waterleaf scarcity. These leaves can therefore provide a nutritional base in Africa (especially Cameroonian) diets for the nutritionally vulnerable in rural and urban communities.

Key words: *Gnetum africanum,* local and exotic varieties, nutrient content, sensory evaluation, sweet potato leaves.

INTRODUCTION

The growing awareness of health promoting and protecting properties of non-nutrient bioactive compounds found in vegetables has directed increased attention to vegetables as vital components of daily diets. In sub-Sahara Africa (SSA) vegetables are important dietary components and they are indispensable ingredients of

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soups or sauces that accompany the common carbohydrate staples. Plant nutrients are the main source of carbohydrates, proteins, minerals and dietary fibre as well as other non-nutrient bioactive compounds. In SSA, tubers crops provide the carbohydrates while leafy vegetables are the major sources of vitamins, dietary fibres, essential amino acids and antioxidants (Fasuyi, 2006). In spite of the recognized health advantages of leafy vegetables, the availability and consumption in tropical and sub-tropical Africa is inadequate partly due to low production, seasonality and susceptibility of these vegetables to various environmental production constraints.

Consequently, a more readily available source of vegetables is needed. Sweet potato (*Ipomoea batatas*) is a crop of great nutritional and health significance mainly due to its beta-carotene and anthocyanin properties (Taylor, 2007). In South Africa, the Agricultural Research Council and Medical Research Council are promoting the consumption of these beta-carotene fortified varieties (Laurie and Faber, 2008). In Tanzania, results of a consumer study showed that beta-carotene-rich sweet potato was more acceptable than the cream-fleshed varieties (Tomlins et al., 2007). The storage roots are often processed into a range of products including flour, chips, infant formulae, breakfast foods and snacks (Tumwegamire et al., 2004). The increased use of yellow/orange flesh storage roots and green shoots of sweet potato could be one important means of alleviating vitamin A deficiency, especially among young children and women in many developing countries (Woolfe, 1992). In some parts of Nigeria, the vines of sweet potato are used as soup ingredients for their flavour, appearance, palatability, and tenderness (Tewe et al., 2003).

Sweet potato leaves are rich in micronutrients and are also consumed in several countries (Mosha and Gaga, 1999). The leaves are an excellent source of antioxidative polyphenolics (Islam et al., 2002). The leaves are consumed as tea in Japan and believed to be medicinal for the treatment of diabetes and help to reduce the risk of colon cancer (Hiroshi et al., 2000). Sweet potato leaves can be harvested almost bimonthly and the crop is generally tolerant to many diseases, pests, flooding and drought. Its leaves can therefore be served as an important source of vegetables to nutritionally deprived populations in sub-Sahara Africa especially during periods of adversity. Despite its importance, little is known in Cameroon about the nutritional content of the leaves of sweet potato. Furthermore, since the nutrient profile of a given crop is influenced by the climatic condition and mode of cultivation, it is important to elucidate the nutritional profiles of the vegetative parts of various local as well as exotic varieties grown and used in Cameroon. There is a wide range of varieties adapted to every ecological zone in Cameroon. This would stimulate interest or increase understanding and the consumption of these health promoting vines by humans.

MATERIALS AND METHODS

Sweet potato varieties

The following six exotic sweet potato varieties, Zapallo, SPK 004 Kakamega, Jewel 566638, Jewel 440331, Jonathan and Tainung obtained from the Institute of Agronomic Research for Development (IRAD) Cameroon and the four local varieties, Buea local, Kekem 2, Mbouda and Santchou obtained from local farmers in Cameroon were used in the study. These varieties were planted in an Experimental Research Plot at the University of Buea, Cameroon. Leaves and vines (shoots) from these varieties were harvested from three to four month old plants and assessed for their nutrient content.

Preparation of sweet potato shoots

Leaf and vine samples were divided into young leaves and young vines. From each sweet potato variety, a stem of about 30 cm long containing leaves was folded into two and then cut; the younger soft parts herein-after referred to as “young leaves” and the rest as “young stems”. Harvested leaves and vines were washed with distilled water to remove dust particles prior to biochemical analysis.

Proximate composition analysis

Moisture content in the samples was determined using the method of Association of Analytical Chemists (AOAC, 1990). Fresh samples were weighed then dried overnight for 24 h at 70°C in a ventilated oven. The samples were weighed again after 24 h then left in the oven at 105°C and dried for 72 h to constant weight. The samples were then cooled in the desiccators, and final weights were taken. The percentage moisture content was calculated as follows: {(fresh mass of sample – dry mass of sample)/fresh mass of sample} x 100%. The percentage dry matter was then calculated as, 100 – (% moisture content).

Ash content was determined following the procedures of AOAC (1990); 0.5 g of the finely milled sample was put in a pre-weighed 10 ml glass beaker and then placed in a muffle furnace set at 450°C for four hours to allow the sample to become ash. It was then cooled overnight in the furnace. The ash content was calculated as follows: {(Weight of beaker with ash – weight of beaker without ash)/weight of sample} x 100%.

Crude protein content was determined by the Kjeldahl method which involved digesting a given mass of the dried sample in sulphuric acid with selenium catalyst. The inorganic nitrogen converted to ammonium sulphate. Percentage nitrogen was then determined by subjecting the digest to a reaction with sodium nitroprusside-sodium salycilate reagent and the absorbance read at 650 nm. Percent nitrogen x 6.25 gave the percentage protein.

Total carbohydrate (sugars + starch) content was determined by the method of Dubois et al. (1956). Sugars were extracted with hot 95% ethanol and the residue subjected to hydrolysis with 70% perchloric acid for starch quantification. The extracts were subjected to colour development using concentrated sulphuric acid and 5% phenol and absorbance read at 490 nm. Crude fat was extracted in hexane by refluxing a given amount of dried sample for four hours in a Soxhlet apparatus at 78°C (Joslyn, 1970).

The calorific values of samples were obtained by multiplying values of crude protein, crude fat and carbohydrate by 4, 9 and 4, respectively (Akubor, 1997). Crude fibre determination was obtained according to the method of Entwistle and Hunter (1949).

Table 1. Proximate composition (%) and the energy contents of young leaves of selected exotic and local sweet potato varieties (mean ± SE).

Variety	Ash	Crude protein	Carbohydrates	Caloric value (Kcal/100 g)
Exotic				
SPK 004 kakamega	13.4 ± 0.2^{d}	19.0 ± 0.4^{b}	35.0 ± 5.0^{a}	248.2^{bc}
Zapallo	14.8 ± 0.3^{e}	22.1 ± 1.0^{c}	33.8 ± 4.9^{a}	265.5^{d}
Jewel 440331	11.9 ± 0.0^{c}	15.5 ± 0.2^{a}	48.8 ± 0.8^{e}	275.4^{d}
Jewel 566638	12.1 ± 0.5^{c}	17.8 ± 0.8^{b}	39.0 ± 0.9^{b}	244.4^{b}
Jonathan	11.9 ± 0.0^{c}	15.1 ± 0.8^{a}	38.3 ± 0.9^{b}	239.7^{b}
Tainung	13.9 ± 0.1^{e}	15.8 ± 0.0^{a}	35.5 ± 0.3^{a}	222.6^{a}
Local				
Buea local	11.5 ± 0.6^{c}	18.6 ± 0.6^{b}	39.9 ± 2.9^{b}	254.5^{c}
Kekem 2	10.4 ± 0.1^{b}	26.3 ± 0.7^{d}	41.8 ± 2.7^{c}	291.8^{e}
Mbouda	9.7 ± 0.1^{a}	26.8 ± 0.4^{d}	40.8 ± 0.3^{c}	294.4^{e}
Santchou	10.2 ± 0.0^{a}	27.1 ± 0.4^{d}	42.6 ± 1.6^{d}	304.0^{e}

Means followed by the same lower case letter in a column are not significantly different at P = 5%.

The dried plant material was defatted in hexane, and the residue was hydrolysed with trichloroacetic acid to eliminate proteins and carbohydrates and then ashed to obtain the mineral content in the sample. The residue resistant to digestion but susceptible to charring was quantified as crude fibre.

Carotenoids were extracted with cold acetone after crushing in a mortar using a pestle. The mixture was then filtered and the filtrate was transferred into a separation funnel. Petroleum ether was added to the extract and the two phases were separated. The lower portion was discarded and the upper portion was washed for a couple of times with distilled water to remove any residual acetone. The petroleum ether phase was transferred into a volumetric flask and residual water removed with sodium sulphate. The volume was then made up to 50 ml with petroleum ether and absorbance measured in a spectrophotometer at 450 nm. A carotenoid standard curve was prepared and used to quantify carotenoids in the leaf samples.

Sensory evaluation

The product used in the sensory evaluation was a popular vegetable sauce in Cameroon often composed of a mixture of the leaves of *G. africanum* popularly known as “eru’ and *T. triangulare* (waterleaf) added as a softener/tenderizer usually in the ration of 1:1. About equal proportions of fresh leaves of *G. africanum* and those of the most popular and widely abundant sweet potato variety in the area “Buea Local” were steamed and then cooked in palm oil with all the required ingredients added as is traditionally prepared. In this case, sweet potato leaves were used in place of *T. triangulare* as the softener/tenderizer. The control was “eru” cooked with *T. triangulare* as is traditionally done. Using a 21-member panel comprised of randomly selected graduate and undergraduate students 10 males and 11 females from the University of Buea, each sauce was served to each consumer in a plate and each asked to assess for colour, texture and taste separately. Panellists were instructed to rinse their mouths before tasting the next sauce. For the assessment, the following verbal anchors were used; ‘preferred, ‘somewhat preferred, ‘neutral/indifferent’, ‘not preferred’ and ‘not preferred at all’. Each panellist was given a score sheet to complete after tasting the sauce. They were not told what each sauce represented.

After the blind assessment of the organoleptic attributes of the sauces, a ‘Yes/No’ question was also asked to the panellists whether they would use sweet potato leaves in place of *T. triangulare* in the preparation of *G. africanum*.

Statistical analysis

Analysis of variance (ANOVA) was carried out on the proximate composition data and differences in means were assessed using least significant difference (LSD) at 5% significance level.

RESULTS

Proximate composition of leaves

The dry matter content of the leaves ranged from 14.7 to 18.6% for the exotic Jewel 56638 and the local variety Mbouda, respectively, while the crude fat composition ranged from 1.9% in the variety Santchou to 4.6% in the Buea local. The crude fat content was generally low compared to the other nutrient components. The percentage of ash, crude protein, total carbohydrates content and caloric values varied greatly among the varieties (Table 1). Among the exotic varieties, the leaves of Zapallo had the highest protein content of 22.1% while among the local varieties Santchou had the highest protein content of 27.1%. In all the varieties studied, leaf protein content was higher than that of the stem. Starch constitutes the bulk of the total carbohydrate content of the young sweet potato stems. Besides Jewel 440331, Kekem 2, Mbouda and Santchou which had the highest carbohydrate leaf content of all varieties studied, the carbohydrate content did not vary much among the others (Table 1).

The contents of proteins, carbohydrates and dry matter

Table 2. Comparative (mean ± SD) combined proximate composition of young stems of exotic and local sweet potatoes (dry weight basis).

Nutrient type	Nutrient content (g/100 g)	
	Exotic	Local
Protein	08.8 ± 1.2[a]	11.3 ± 1.9[a]
Ash	15.9 ± 1.4[a]	07.7 ± 1.3[b]
Sugars	12.0 ± 2.6[a]	12.9 ± 2.2[a]
Starch	32.2 ± 3.6[a]	37.2 ± 3.9[b]
Total carbohydrates	44.2 ± 4.0[a]	50.1 ± 5.3[b]
Dry matter	12.9 ± 1.2[a]	18.4 ± 1.3[b]
Crude fibre	29.3 ± 1.4[a]	27.3 ± 2.5[a]
Crude fat	02.1 ± 0.4[a]	02.3 ± 0.8[a]
Caloric value (kcal/100 g)	231.5 ± 17.5[a]	265.9 ± 22.2[b]

Means followed by the same lower case letter in a row are not significantly different at P = 5%, Student t-test.

were generally higher in the local varieties than in the exotics. The local variety Mbouda had the highest leaf dry matter content of 18.6/100 g of fresh weight. In contrast, crude fibre and ash contents were generally higher in the exotic than the local varieties both in the leaves and stems (Table 2).

There were varietal differences in the crude fibre content with SPK 004 Kakamega having the highest in the leaves and stems among the exotic varieties while Mbouda had the highest values among the local varieties. The highest and lowest leaf carotenoid content of 3556.9 and 1414.6 ug/100 g was recorded for the Mbouda and Santchou local varieties, respectively (Table 3).

Sensory evaluation of sweet potato leaves in "eru" (*Gnetum africanum)* sauce

Young sweet potato leaves were found to tenderize *G. africanum* "eru" vegetable sauce similar to the traditionally used tenderizer *T. triangulare*. Roughly 85% of the panellists preferred the colour of the sweet potato-based sauce, 15% somewhat preferred it or were neutral/indifferent compared to 76 and 20%, respectively, for the *T. triangulare*-based that served as the control sauce. Based only on the colour, it was almost impossible to differentiate between the sauce prepared with leaves of the Buea local sweet potato variety and that prepared with *T. triangulare* (waterleaf). With regard to taste, about 43% preferred or somewhat preferred the sweet potato-based sauce, 33% were neutral/indifferent compared to 61 and 28%, respectively for the control (Table 4). In regard to the texture, 15% either preferred or somewhat preferred the sweet potato-based sauce and around 47% were neutral or indifferent as opposed to about 71 and 19%, respectively for the *T. triangulare*-based control sauce. Overall, 80% of the panellists indicated a readiness to use sweet potato leaves as a substitute for *T. triangulare* (waterleaf) to prepare the *G. africanum* sauce if waterleaf was unavailable as would be the case during the dry season.

DISCUSSION

The nutritional composition of sweet potato leaves and storage roots varies widely across varieties as dictated by genetic differences. The range for sweet potato leaf protein obtained in this study is consistent with the range reported by Oduro et al. (2008) (16.78 to 25.39%) with the local varieties Kekem 2, Mbouda and Santchou having the highest values of about 26% in this study. These values were compared favourably with those of cassava and other leaves that are consumed in Africa (Akindahunsi and Salawu, 2005). Hence, sweet potato leaves can be served as a good source of dietary protein comparable or in some cases superior to those of amaranth, taro, pumpkin and okra (FAO, 2006) that are widely consumed as leafy vegetables in Africa. Although, sweet potato is often considered as a food source for the poor in most parts of Africa (Adu-kwarteng et al., 2001), it remains a nutrient-rich food that can alleviate nutritional deficiencies in most parts of the continent.

Sweet potato leaves are often harvested together with the young tender apical portions of the vine; therefore nutrients contained in these portions would supplement those in the leaves. The crude fibre content was generally higher in the vines than leaves understandably so because the vine plays a supportive role in the plant and therefore requires tougher and fibrous tissues consistent with this function. The mean fibre content of the leaves was close to the values reported by Tewe (1994) but higher than those of Antia et al. (2006). This disparity is probably due to varietal differences and/or differences in climatic conditions. Overall, the leaves of sweet potato have lower fibre content than those of other tropical root crops such as cassava. The low fibre content coupled with the high moisture content of sweet potato

Table 3. Micronutrient content of young leaves and stems of selected exotic and local sweet potato varieties on fresh weight basis (FWB).

Variety	Crude fibre (g/100 g)		Total carotenoid (ug/100 g)
Exotic	**Young leaves**	**Stems**	**Leaves**
SPK 004 Kakamega	4.7 ± 0.3	4.6 ± 0.3	1508.9 ± 75.5
Zapallo	4.1 ± 0.2	3.4 ± 0.2	3154.5 ± 157.7
Jowel 440331	3.3 ± 0.1	3.5 ± 0.2	2291.9 ± 144.6
Jowel 566638	3.5 ± 0.2	4.1 ± 0.3	1650.8 ± 82.2
Jonathan	3.6 ± 0.2	4.2 ± 0.3	1483.4 ± 74.2
Tainung	2.7 ± 0.1	3.4 ± 0.2	1979.5 ± 99.0
Mean ± SD	3.6 ± 0.7	3.9 ± 0.5	2011.5 ± 639.9
Local			
Mbouda	4.5 ± 0.3	5.3 ± 0.4	3556.9 ± 177.8
Buea local	3.0 ± 0.2	5.1 ± 0.3	1851.6 ± 92.9
Kekem 2	2.4 ± 0.1	4.1 ± 0.2	1609.1 ± 80.5
Santchou	3.4 ± 0.2	5.5 ± 0.4	1414.6 ± 70.7
Mean ± SD	3.3 ± 0.9	5.0 ± 0.6	2108.1 ± 602.7

Table 4. Consumer preferences (%) for *Gnetum africanum* vegetable sauce softened with either *Talinum triangulare* (control) or leaves of the Buea local sweet potato variety.

Sensory attribute	Verbal anchor	Type of sauce/preference (%)	
		G. africanum* + *T. triangulare	***G. africanum* + Sweet potato leaves**
Colour	Preferred	76.2^{a}	85.7^{b}
	Somewhat preferred	4.8^{a}	9.5^{a}
	Neutral/Indifferent	19.0^{b}	4.8^{a}
	Not preferred	0.0^{a}	0.0^{a}
	Not preferred at all	0.0^{a}	0.0^{a}
Taste	Preferred	38.1^{a}	9.5^{b}
	Somewhat preferred	23.8^{a}	33.3^{b}
	Neutral/Indifferent	28.6^{a}	33.3^{a}
	Not preferred	9.5^{a}	19.0^{b}
	Not preferred at all	0.0^{a}	4.8^{a}
Texture	Preferred	47.6^{b}	4.8^{a}
	Somewhat preferred	23.8^{b}	9.5^{a}
	Neutral/Indifferent	19.0^{a}	47.6^{b}
	Not preferred	9.0^{a}	28.6^{b}
	Not preferred at all	0.0^{a}	9.5^{b}

Means followed by the same lower case letter in a row are not significantly different at P = 5%, Student t-test.

leaves likely makes them generally much tender than cassava leaves. The relatively tender nature and acceptable fibre content of the leaves and vines of sweet potato renders them easily digestible.

Dietary fibres facilitate digestion and are reported to prevent colon cancers (Saldanha, 1995). Thus, making sweet potato leaves an important component of many diets. Starch constituted the bulk of the total carbohydrate content in both the leaves and stems. The range (35.00 to 56.71%) is comparable to that reported by Antia et al. (2006). This high starch content makes the leaves a good source of energy in addition to its improved nutrient status and health benefits mediated by the high total carotenoid levels. We can conclude that consumption of sweet potato leaves rich in dietary fibre, vitamins and antioxidants in the form of carotenoids would be useful in neutralizing free radicals in the body and hence reduce the harmful effects of oxidative stress (Teow et al., 2007). The addition of *G. africanum* to sweet potato leaves was acceptable particularly because its appearance and the mixture and preparation did not alter the organoleptic attributes of the sauce (Laurie and Van Heerden, 2012). A possible reason for 33% of the panellists being neutral/indifferent regarding the taste of the sauce is because it was the first time of tasting a *G. africanum*-based sauce of a slightly different flavour from what they are accustomed to. It is highly likely that if the panellists had been offered the sweet potato based sauce subsequently, many of these neutral respondents would have readily accepted the taste of the sauce. This is buttressed by the fact that 80% of the respondents indicated that they would readily use sweet potato leaves as a substitute for *T. triangulare* in the preparation of the *G. africanum* if *T. triangulare* was unavailable. Replacement of *T. triangulare* with beta-carotene-rich sweet potato leaves in the preparation of *G. africanum* can be a good strategy to increase the consumption of diets rich in antioxidants. Ofori et al. (2009) indicated that sweet potato varieties with high levels of beta-carotene in their leaves and roots are potential food-based candidates for alleviating Vitamin A deficiency in Africa. Since we tested only one of the sweet potato varieties, it is possible that other varieties might be preferred even more. Further studies would be conducted to verify this possibility.

Given the acceptable taste, diverse and important nutritional components of sweet potato shoots (leaves and stems), hardiness and tolerance of the crop to high humidity detrimental to other leafy vegetables, sweet potato shoots can therefore be served as a rich and versatile vegetable to supplement the predominantly starchy dietary staples in most areas of rural sub-Sahara Africa. The consumption of beta-carotene-rich sweet potato leaves as strategy of addressing Vitamin A deficiency needs to be widely disseminated especially in rural communities where the consumption of leafy vegetables is highest because of their increased availability in remote areas.

Conclusion

The sweet potato-based sauce had an acceptable appearance, texture, flavour and taste. Most respondents of a sensory evaluation panel indicated that they will readily use sweet potato leaves in the preparation of the *G. africanum* sauce in the absence or during scarcity of *T. triangulare*. A wide dissemination of the use of beta-carotene fortified sweet potato leaves in the preparation of *G. africanum* sauce would be a good means of increasing the consumption of vitamin A and other functional micronutrients in some diets of many Africans especially those in rural areas where the consumption of vegetables is highest.

Conflict of Interests

The authors have not declared any conflict of interests.

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