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Full Length Research Paper

Assessment of vitamin A content and sensory attributes of new sweet potato (*Ipomoea batatas*) genotypes in Ghana

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A study was conducted to assay the vitamin A contents of the leaves and roots of twenty four (24) newly bred sweet potato varieties and also assess the sensory attributes of the roots. Four months old genotypes of sweet potato leaves and roots were obtained from Fiaso, in the Brong Ahafo Region of Ghana, and were analysed using the reverse phase HPLC techniques for their –, ß– and total carotenoid contents. A farmer participatory approach was used in the assessment of the sensory attributes of both boiled and fried samples of sweet potato roots. *Xushu* 18 was the most preferred variety, followed by *TIS 2534* and *Beauregard 566613* for the boiled roots. *SPK 004* was the best preferred variety for the fried roots, followed by *VSP 4* and *Beauregard 566613*. The fresh sweet potato leaves recorded total carotenoid levels of 2228 – 9173.8 µg/100 g, -carotene of 508.7–3660.8 µg/100 g and - carotene of 34.4 – 1904.6 µg/100 g. The data obtained for the roots ranged from 225.4 – 5243 µg/100 g for total carotenoid, 13 – 2145.6 µg/100 g for -carotene and traces of -carotene with the exception of 8 samples that recorded values in the range of 0.1 to 473.9 µg/100 g. It was observed that varieties or genotypes with high levels of leaf provitamin A carotenoid recorded low values in roots and vice versa. -carotene was the most dominant provitamin A carotenoid in both the leaves and roots of the sweet potato varieties. Varieties with high levels of carotenoid for both leaves and roots can therefore play a complementary role in initiatives designed to reduce vitamin A deficiency.

Key words: Carotenoids, roots, participatory approach, complementary.

INTRODUCTION

Sweet potato (*Ipomoea batatas*) is an important crop with an annual world/global production of over 122 million metric tonnes, and grown in over 166 countries. Annual production in Africa is estimated at over 7 million tonnes (Kapinga et al., 2001). In Sub-Saharan Africa, it is the third most important root crop, after cassava and yam (Scott and Ewell, 1992) . Proximate composition, mineral and vitamin content of sweet potato compares favourably with various fruits and vegetables although several varieties are known to contain higher levels of minerals and proteins than other vegetables (Woolfe, 1992). These desirable qualities place sweet potato in a unique position in the quest to improve food security and eliminate malnutrition in various communities around the world.

According to Kapinga et al. (2001), most sweet potato varieties grown in Africa, including Ghana, are white or yellow-fleshed (W/YFSP) and these supply little vitamin A when incorporated into a diet. However, the orange-fleshed sweet potato (OFSP) has been identified as a variety that can make a major contribution in the alleviation of vitamin malnutrition in Sub-Saharan Africa (Hagen-imana et al., 1999). This is due to its association with high content of provitamin A carotenoid – notably -carotene. The potential of the leaves as a source of nutrients also appears to be largely unexploited.

In Ghana, a careful examination of the menus of most food services and households reveal that sweet potato is not very well integrated into the average Ghanaian diet. This apparent poor integration has been partly attributed to limitations in product diversity and the perception that sweet

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potato is the poor man's food (Adu-Kwarteng et al., 2001; Oduro et al., 2001). The development of appealing processed products from sweet potatoes will therefore play a major role in raising awareness on the potential of the crop.

Sensory attributes such as appearance, taste, texture, stickiness and softness could contribute immensely to the acceptability or otherwise of any food crop. Kader (1985) reported that factors such as appearance (visual), flavour (taste and smell), texture (feel), nutritive value and safety are very important criteria for assessing the quality of processed sweet potato roots.

Research towards the breeding of new varieties with different nutrient characteristics is receiving attention in some laboratories especially in Africa. One of such research has resulted in the release of new varieties by breeders at the Crops Research Institute (CRI) of Ghana. The Crops Research Institute of Ghana has released some orange-fleshed sweet potato (OFSP) genotypes and is also evaluating a number of other genotypes. Thus, more studies are needed to evaluate these newly bred varieties and genotypes for their potential to fit well into the traditional feeding practices of the communities as well as for their Vitamin A content.

The objective of this study was to assay the vitamin A contents of the leaves and roots of twenty four (24) newly bred sweet potato varieties and also assess the sensory attributes (appearance, taste, texture, stickiness, and softness) of the roots using farmers' participatory approach.

MATERIALS AND METHOD

Sample source

Leaf and root samples were obtained from four months old sweet potato genotypes on farm evaluation trials from Fiaso, near Techiman, in the Brong Ahafo region of Ghana. The varieties or genotypes under evaluation were *Beauregard 566613, Xushu 18, Salyboro, TIS 83/0138, TIB-4, Excel 440016, BP-SP- 2, NC-1560, 440-443, Nemanete, Jewel 566638, Camote Rosita, Tainung No 64, Jewel 440031, TIS 2534, VSP 4, Resisto, 199062.1, 440203, Kandee, CN 1448-59 , 199005.11, SPK 004, Comensal* and *Apomuden*, a locally grown improved orange-fleshed sweet potato was used as control.

Carotenoid determination

The carotenoid analyses were carried out at the Nutrition Department of the Noguchi Memorial Institute for Medical Research (NMIMR), University of Ghana, Legon, using a reverse phase high performance liquid chromatography (HPLC) methodology previously developed by Takyi (1999). All samples were refrigerated prior to the analyses. The analyses were performed in a dark room due to the light sensitive nature of carotenoid.

Fresh leaf sample (0.03 g) from each variety was weighed in duplicate into previously weighed porcelain mortars. The sample was ground with pestle in 2 ml HPLC grade cold acetone until a fine slurry was obtained. A micropipette was used to siphon the extract and the procedure repeated until the residue became colourless. The extracts were then evaporated to dryness with nitrogen gas. A pinch of pyrogallol was added (to remove oxygen as the presence of oxygen could lead to oxidation of the carotenoid) and 600 µL of petroleum spirit and 400 µL of 15% methanolic potassium hydroxide was added. This was mixed thoroughly with the aid of a mixer and allowed to saponify overnight at room temperature in the dark. The extract was centrifuged at 14000 rpm for 2 min and the supernatant removed. The colourless extracts were evaporated to dryness with nitrogen gas and reconstituted with 300 µL of the mobile phase (l% tetrahydrofuran in methanol). After thorough mixing, 120 µL of the resultant aliquot was injected into the HPLC (Shimadzu LC-6 A: U.V Visible detector SPD-6 AV; Wavelength of detection-450 nm; Column-Monomeric C_{18}, Vydac-218 TP54; Isocratic elu-tion, flow rate, 1 mL/ min).

A carotenoid standard prepared from an extract of *Camote Rosita* was obtained. A spectrophotometer was used to determine the concentration of the standard and this was used to quantify carotenoids in the fresh leaf sample. Areas corresponding to the different retention times of the carotenoids under investigation were used to calculate the concentrations (Rodriguez-Amaya and Kimura, 2004). The method for determining the carotenoid concentrations in the fresh roots was similar to that used for the fresh leaves with the exception of the saponification step. Furthermore, a greater quantity, 0.08-0.09 g of the fresh root samples was taken for the cream to white-fleshed varieties; as such an amount was required to make detection by the HPLC a possibility.

Evaluation of sensory attributes

A farmer participatory approach was used in the evaluation of sensory attributes of the sweet potato varieties. The farmers' assessment of both field and sensory attributes represent an important constituency in the decision to release new crop varieties. Their involvement in the evaluation was therefore considered to be crucial. The evaluation was conducted a day after the roots were harvested. A five member panel of regular consumers of sweet potato, representing the different households in the community, was served with the prepared sweet potato food samples.

Three representative samples, about 8 cm long and 4 cm diameter of each variety were placed in a labelled polythene bag and cooked in pre-heated (boiling) water for 15 min. The cooked food samples from each variety were then served to the panel who were asked to asses them on a scale of l to 5, with 1 representing "very poor" and 5, "very good", on parameters such as appearance, taste, texture, stickiness, and softness.

Representative samples of each variety were also knife-peeled and washed in water. The water was then drained and the roots fried, in batches, in hot oil for 8 min before being served to the panel. The panellist's score for each variety was averaged. Appearance examination was carried out through the panellist's visual assessment of the boiled and fried sweet potato varieties as they were served. Texture was assessed by pressing the boiled or fried sample in-between the fingers.

Statistical analysis

A completely randomized design was used to study the effects of varietal differences on and -carotenes as well as total carotenoid contents in the leaves and roots of the new sweet potato varieties. Analysis of variance (ANOVA) was carried out on the carotenoid data obtained and the differences in means were assessed with Least Significant Difference (LSD) test using CoStat statistical software. Evaluation of sensory attributes (appearance, taste, texture, stickiness, and softness) was performed on the sweet potato roots and the data obtained analysed with the Friedman test.

Table 1. Total carotenoids: - and ß-carotene content of fresh leaves.

Cultivar name	Total carotenoid (µg/100 g fresh tissue ± S D)	-carotene (µg/l00 g fresh tissue ± S D)	-carotene (µg/100 g fresh tissue ± SD)
Excel 440016	9173.8 ± 2339$_{a}$	3860.7 ± 382$_{a}$	171.1 ± 51$_{ab}$
Nemanete	7419.0 ± 304$_{ab}$	1115.0 ± 14$_{fghij}$	190.4 ± 24$_{a}$
TIB-4	6464.6 ± 576$_{bc}$	2536.3 ± 376$_{b}$	143.6 ± 35$_{abc}$
199005.11	6082.6 ± 224$_{bcd}$	2351.0 ± 102$_{b}$	75.1 ± 61$_{defgh}$
NC 1560	5978.3 ± 490$_{bcd}$	221O.7 ± 293$_{bc}$	131.5 ±31$_{abcd}$
199062.1	5357.7 ± 557$_{cde}$	940.6 ± 104$_{ghij}$	119.6 ± 20$_{bcde}$
440443	5157.7 ± 257$_{cdef}$	1934.2 ± 133$_{bcde}$	34.4 ± 45$_{hi}$
Resisto	4935.6 ±35$_{cdef}$	171O.6 ± 218$_{cdef}$	108.2 ± 63$_{bcdef}$
TIS 2534	4601.1 ± 916$_{def}$	1617.9 ± 29$_{cdef}$	78.9 ± 2$_{defgh}$
SPK 004	4490.7 ± 537$_{defg}$	1699.5 ± 379$_{cdef}$	69.8 ±19$_{defgh}$
TIS 83/0138	4400.8 ± 129$_{defg}$	1443.3±103$_{efgh}$	56.8 ± 12$_{efghi}$
Xushu 18	3945.2 ± 407$_{efgh}$	1561.6 ± 271$_{defg}$	*Traces*$_{i}$
Jewel 440031	3926.0 ± 522$_{efgh}$	1466.7 ± 190$_{efgh}$	50.5 ±8$_{fghi}$
Salyboro	3614.4 ± 232$_{efgh}$	1154.5 ± 59$_{fghi}$	49.5 ± 9$_{fghi}$
BP-SP-2	3602.9 ± 645$_{efgh}$	663.9 ±78$_{ij}$	106.9 ± 12$_{cdefg}$
Kandee	3465.8 ± 242$_{fgh}$	1429.1 ± 94$_{efgh}$	66.3 ± 8$_{efgh}$
440203	2771.8 ± 503$_{gh}$	542.9 ± 2$_{ij}$	88.7 ± 8$_{cdefgh}$
Camote Rosita	2756.8 ± 323$_{gh}$	2136.7 ± 220$_{bcd}$	63.6 ± 37$_{efghi}$
Beauregard 566613	2483.0 ± 187$_{h}$	508.7 ± 4$_{i}$	69.5 ± 5$_{defgh}$
CN 1448-59	2228.2 ± 313$_{h}$	843.3 ± 160$_{hij}$	43.3 ± 19$_{ghi}$
Comensal	ND*	ND*	*ND**
Tainung No 64	ND*	ND*	*ND**
Apomuden	ND*	ND*	*ND**
VSP4	ND*	ND*	*ND**
Jewel 566638	ND*	ND*	*ND**

ND* - Not Determined
Means with the same subscripts, within columns, are not significantly different ($p < 0.05$).

RESULTS AND DISCUSSION

Carotenoid analysis of Leaves

-carotene

-carotene was the most dominant provitamin A carotenoid for the fresh leaf samples of the sweet potato varieties. Excel 440016 had the highest -carotene content (3860.7 µg/l00 g), while the least was recorded for *Beauregard* 566613 (508.7 µg/100 g) (Table 1). According to Rodriguez-Amaya (1997), -carotene is the most important provitamin A carotenoid, both in terms of bioactivity and widespread occurrence. The pattern of results obtained for the -carotene content in the fresh leaves confirms the higher levels of -carotene. Generally, the -carotene content recorded for the fresh leaf samples were also greater than those for the fresh roots.

In India, leafy vegetables have been grouped on the basis of -carotene content into high (4600- 7400 µg/l00 g), moderate (2500-3900 µg/l00 g), and low (1200-2300 µg/l00 g), (Begum and Pereira, 1977; Rodriguez-Amaya, 1997). On the basis of this classification, Excel 440016, and T1B-4 could be described as having moderate levels of the -carotene in their leaves. Varieties such as *199-005.11*, *NC 1560*, *Camote Rosita*, *440443*, *Resisto SPK 004*, *TIS 2534*, *Xushu 18, Jewel 440031*, *TIS 83/ 0138*, and *Kandee* could be described as having low levels of -carotene in their leaves. The –carotene levels recorded for leaves from varieties such as *Salyboro, Nemanete*, *199062.1*, *CN 1448-59, BP- SP-2, 44020*, and *Beauregard* 566613 could also be described as very low on the basis of the classification in India.

The significant differences ($p < 0.05$) in the -carotene content recorded among the fresh leaf samples could be attributed to varietal differences. Rodriguez-Amaya and Kimura (2004) reported that in a given food, qualitative as well as quantitative differences exist due to factors such as cultivar/ variety. The level of the -carotene recorded for *Excel* 440016 compares favourably with the levels obtained in Bitter melon leaves (*Momordica charantia*), 3400 µg/g, (Speek et al., 1988), and Amaranth leaves (*Amaranthus viridis*), 1500-3900 µg/g (Wasantwisut et al., 1995). However, higher levels of -carotene (5300- µg/100g) have been reported in Spinach leaves (*Spinacea oleracea*) (Abdel-Kader, 1991). Jalal et al. (1998 reported that a food based approach could be a successful way of reducing the prevalence of vitamin A deficiency, and in Ghana, consumption of cassava and Kapok leaves with a -carotene level of 1000 µg/l00 g and 3850µg/I00 g, respectively has been reported to increase serum reti-nol levels (Takyi, 1999). *Excel* 440016, TIB-4 and 1990-05.1, among others, could therefore play a very signify-cant role in any food based approach aimed at reducing the incidence of vitamin A deficiency.

-carotene

Nemanete had the highest -carotene content (190.4 µg/l00 g), while *Xushu 18* had traces (Table 1). The re-sults of the analysis confirm the relatively lower -caro-tene levels associated with foods known to be good sour-ces of provitamin A. Best (1990), working on fresh carrots and spinach, reported a -carotene content of 8.8 mg/ l00 g and 5.6 mg/ 100 g, respectively, while for -carotene only traces were recorded. In the same study, Best (19-90) also reported a -carotene content of 6.9 mg/l00 g for canned pumpkin while for -carotene, a value of 4.8 mg/ l00 g was recorded. Varieties like *Nemanete, Excel 440-016 and TIB*-4 could therefore be said to contain sub-stantial levels of -carotene with the potential to contri-bute to any initiative designed to reduce vitamin A defi-ciency.

Total carotenoid

The highest total carotenoid content for the fresh sweet potato leaf samples was recorded for *Excel* 440016 (9173.8 µg/l00g), while the lowest was for *CN* 1448-59 (2228.2 µg/l00 g) (Table 1). Significant differences (p< 0.05) were also recorded for the total carotenoid content among the fresh leaf samples and this could be attributed to varietal differences. The results also show that the lea-ves of sweet potato varieties such as *Excel* 440016*, N-emanete,* and *TIB- 4* could serve as a credible source of carotenoid, with all the beneficial health effects.

Recent studies have associated the consumption of foods rich in carotenoid with decreased incidence of cer-tain cancers in humans (Gester, 1993). Carotenoids have also been linked with enhancement of the immune sys-tem and decreased risk of degenerative diseases such as cardiovascular disease, age- related muscular degene-ration and cataract formation (Buyers and Perry, 1992). The fresh leaves of varieties like *Excel* 440016, *Nemane-te, TIB-4* and *199005.11* could therefore play a crucial role in any policy intervention aimed at encouraging the consumption of carotenoid rich foods for beneficial health effects.

Carotenoid analysis of roots

–carotene

The highest -carotene content was recorded for *Beau-regard* 566613 (2145.6 µg/100 g) and the least content for *440203* (Traces). The relatively higher levels of the -car-otene obtained for varieties such as *Beauregard* 566613, *Jewel 440031, Camote Rosita* and *TIB*-4, compared with the locally grown *Apomuden,* makes them a credible po-tential source of vitamin A. -carotene has been associ-ated with several beneficial health effects. Studies have shown a consistent association of increased lung cancer risk with low dietary -carotene or serum - carotene con-centrations (Holick et al*.,* 2002). The levels of the -caro-tene recorded for the sweet potato roots also confirm the dominance of -carotene as a widely occurring natural pigment. Rodriguez-Amaya (1997) reported that - caro-tene is the most important provitamin A carotenoid, both in terms of bioactivity and widespread occurrence. It has also been designated as the most potent provitamin A (Rodriguez-Amaya, 1993). The -carotene levels associ-ated with the sweet potato genotypes studied also con-firm the variation of -carotene levels in sweet potato crops. According to Takahata et al*.* (1993), -carotene content of sweet potato varies greatly and a mean range of between 10 to 26,600 µg/100g has been reported.

The relatively high -carotene content recorded for *Beauregard* 566613 could be attributed to the orange flesh colour of the root. Simon (1997) reported that -carotene serves as an important nutritional component in foods as a major precursor of vitamin A, and it provides a pleasant yellow to orange colour to foods.

The -carotene level recorded for *Beauregard* 566613 also compares favourably with values reported by Hage-nimana et al*.* (1999) for *CIP420004* (2671.9 µg/100g). *Beauregard* 566613 could therefore play a crucial role in any food based approach to fight the incidence of vitamin A deficiency. Hagenimana et al*.* (1999) have also report-ted a - carotene level of 111.8 µg/100 g for *Xushu* 18. The low levels of the -carotene recorded for the same variety in the current study, compared to what has been associated with the same cultivar in other regions of the world, could be attributed to climate/ geographical condi-tions at the site of production. The same reason may ac-count for the significant differences (p<0.05) recorded among the orange fleshed varieties.

-carotene

Generally, -carotene values were relatively low com-pared to the - carotene. Variety *199062.1* had the high-est -carotene content in the roots (473.9 µg/100 g), while the other sweet potato genotypes had low levels or traces of the -carotene. There appears to be little work done as to the documentation of -carotene levels in sweet potato. The relatively low levels of -carotene re-corded for most of the roots, however confirm the dom-inance of -carotene as far as provitamin A carotenoids are concerned.

Best (1990) reported that -carotenes are ten times more anti-carcinogenic than -carotene. He also reported a -carotene content of 9.5 mg/ 100 g for baked sweet potato while -carotene level was present in trace amounts. In the same study, fresh carrots yielded 8.8 mg/ 100 g for -

Table 2. Total carotenoid, and -carotene content of the fresh roots.

Cultivar name	Total Carotenoid (µg/100 g fresh tissue ± SD)	-Carotene (µg/l00 g fresh tissue ± SD)	-Carotene (µg/100 g fresh ± SD)
*Beauregard*566613	5243.1 ± 1930$_{a}$	2145.6 ± 865$_{a}$	*Traces*
Jewel 440031	2609.0 ± 1109$_{b}$	868.7 ± 414$_{b}$	*Traces*
Camote Rosita	2119.0 ± 177$_{bc}$	645.5 ± 58$_{bc}$	*Traces*
TIB-4	1700.5 ± 580$_{bcd}$	633.8 ± 261$_{bc}$	*Traces*
SPK-004	1506.8 ± 855$_{bcde}$	420.8 ± 351$_{bcdef}$	*Traces*
Tainung No 64	1364.8 ± 183$_{cdef}$	431.0 ± 95$_{bcdef}$	*Traces*
199062.1	1292.0 ± 26$_{cdef}$	464.7 ± 26$_{bcde}$	473.9 ± 75$_{a}$
Kandee	1291.0 ± 207$_{cdef}$	515.5 ± 80$_{bcd}$	*Traces*
Comensal	923.4 ± 169$_{defg}$	171.6 ± 2$_{def}$	0.1 ± 0$_{b}$
Jewel 566638	890.5 ± 207$_{defg}$	219.7 ± 37$_{cdef}$	0.7 ± 0.2$_{b}$
Salyboro	788.3 ± 169$_{defg}$	282.8 ± 81$_{cdef}$	*Traces*
CN 1448-59	674.4 ± 44$_{defg}$	108.2 ± 7$_{def}$	*Traces*
VSP4	673.4 ± 15$_{defg}$	96.3 ± 56$_{def}$	0.3 ± 0$_{b}$
Apomuden	629.1 ± 722$_{defg}$	91.5 ± 62$_{def}$	8.0 ± 6$_{b}$
NC 1560	552.3 ± 28$_{defg}$	132.1 ± 8$_{def}$	*Traces*
Resisto	423.1 ± 471$_{efgh}$	171.5 ± 119$_{def}$	4.0 ± 5$_{b}$
199005.11	359.1 ± 136$_{efgh}$	159.0 ± 60$_{def}$	*Traces*
TIS 83/0138	275.2 ± 26$_{fg}$	13.7 ± 3.9$_{ef}$	2.2 ± l$_{b}$
440443	264.5 ± 58$_{fg}$	13.5 ± 0.8$_{ef}$	1.6 ± 0.2$_{b}$
BP-SP-2	225.4 ± 18$_{fg}$	28.5 ± 2$_{ef}$	*Traces*
Excel 440016	23.9 ± 6$_{g}$	11.17 ± 3$_{ef}$	*Traces*
440203	21.4 ± 16$_{g}$	*Traces*	*Traces*
Xushu 18	17.3 ± 3$_{g}$	7.37 ± 1$_{f}$	*Traces*
TIS 2534	4.9 ± 0.5$_{g}$	2.87 ± 1$_{f}$	*Traces*
Nemanete	*ND**	*ND**	*ND**

N D * - Not Determined
Means with the same subscripts within columns are not significantly different (p< 0.05).

carotene while -carotene was reported to be 4.6 mg/ 100 g. The -carotene levels recorded for *199062.1* could therefore be said to be high, when compared to what has been associated with other foods highlighted above.

Total carotenoid

The carotenoid analysis of the roots of the various genotypes is presented in Table 2. Among the fresh sweet potato roots, *Beauregard* 566613 had the highest total carotenoids (5243.14 µg/100 g), while *TIS* 2534 had the lowest (4.52 µg/100 g). The results confirm the widely distributed nature of carotenoids of plant origin.

For sweet potato, total carotenoid levels ranging from 390.9 to 8823.5 µg/100 g have been recorded for some orange-fleshed varieties (Hagenimana et al*.,* 1999). The relatively higher levels of total carotenoids associated with varieties such as *Beauregard* 566613, *Jewel 440031, 199062.1, and Camote Rosita* could be attributed to their orange flesh colour conferred on them by the high -carotene content. Orange flesh sweet potato varieties have been identified as a rich source of carotenoids. For example, Hagenimana et al*.* (1999), reported total carotenoid level 8942.5 µg/100 g for *CIP 420010* (Teoboza), an orange-fleshed variety.

Another important observation is the relatively higher total carotenoid levels obtained for varieties such as *Beauregard* 566613, *Jewel 440031, 199062.1* and *Camote Rosita,* compared with *Apomuden,* the local orange flesh variety. The varieties with relatively higher levels of the total carotenoids could be described as having a greater potential to supply carotenoids, compared to the locally grown variety. The significant differences (p<0.05) in total carotenoid levels obtained among the fresh sweet potato roots could be attributed to varietal differences (Rodriguez-Amaya and Kimura, 2004).

The roots of Beauregard 566613 contained relatively high levels of -carotene, in addition to the good sensory attributes. *Beauregard* 566613 with its high level of -carotene and good performance in the farmers' assessment could therefore play a very crucial complementary role in the fight against vitamin A deficiency in several communities of Ghana and other developing countries where sweet potatoes is a staple.

Table 3. Sensory score for boiled roots of sweet potato genotypes.

Varieties	Sensory attribute				
	Appearance	**Taste**	**Texture**	**Stickiness**	**Softness**
Beauregard 566613	5.0	3.6	5.0	3.6	2.6
Xushu 18	3.8	2.8	4.6	3.8	3.6
Salyboro	3.4	3.0	5.0	2.6	2.4
Apomuden	3.2	2.8	3.4	2.4	2.0
TIS 83/ 0138	4.0	4.6	4.6	2.6	3.0
TIB-4	3.6	4.4	4.2	2.2	3.4
Excel 440016	3.0	2.0	4.0	2.0	3.2
BP-SP-2	3.2	4.4	1.8	2.8	2.2
NC-1560	4.0	3.0	3.4	4.0	1.6
440443	3.8	3.8	3.8	2.0	2.6
Nemanete	2.8	3.8	3.6	2.8	3.6
Jewel 566638	3.0	2.6	3.0	2.0	3.0
Camote Rosita	3.0	3.0	4.6	3.6	2.6
Tainung No 64	4.6	4.0	3.4	2.2	1.8
Jewel 440031	4.6	4.0	3.4	2.2	1.8
TIS 2534	4.6	3.8	2.8	3.0	2.6
VSP 4	2.6	4.6	4.4	4.0	4.4
Resisto	3.0	3.6	3.8	3.0	3.6
199062.1	4.0	4.0	4.6	2.6	3.6
440203	3.6	3.0	4.6	2.0	2.6
Kandee	2.6	4.4	2.8	3.0	4.0
CN 1448-59	2.6	4.6	2.0	4.0	2.6
199005.11	3.8	2.8	4.6	3.8	3.6
SPK 004	2.6	3.0	4.0	2.0	3.0
Comensal	3.6	3.4	4.0	2.4	3.2
p	0.00	0.00	0.00	0.00	0.00

Sensory evaluation of boiled roots

Appearance

The results of the boiled roots are presented in Table 3. The assessment of the boiled roots showed that *Beauregard* 566613 was the most preferred in terms of appearance while varieties like *Kandee* and *CN* 1448-59 were the least preferred. *Beauregard* 566613 was also selected as the best in terms of texture of the boiled sweet potato roots. According to Kader (1985), factors such as appearance (visual), flavour (taste and smell), texture (feel), nutritive value and safety are very important criteria for assessing the quality of processed sweet potato roots.

Taste

For the boiled root samples, *TIS* 83/ *0138, VSP* 4 and *CN* 1448 -59 were the most preferred, while *Excel* 440016 was least preferred. Taste relates to the panellist's assessment of the sweetness level of the boiled varieties. The sweetness level of sweet potato can influence the area of its utilization. Adu-Kwarteng et al*.* (2001) reported that for products such as snack foods and desserts, the sweet taste is highly preferred, whereas in the case of "fufu", sweetness is considered as undesirable by many consumers.

Softness

Kandee was the most preferred variety, while *NC*-1560 was least preferred in terms of softness of the boiled roots. The softness of boiled food is generally influenced by the cooking time. According to Bradbury and Holloway (1988) , different varieties have different cooking times due to inherent variations in starch content, composition, as well as the levels of soluble and insoluble fibres. The performance of varieties such as NC-1560, *Jewel* 440031 and *Tainung* No 64 with respect to the softness of the boiled roots indicates that such varieties would require shorter

Table 4. Friedman test ranking of boiled roots.

Variety	Mean rank
Xushu 18	19.8
TIS 2534	18.6
Beauregard	18.2
Resisto	18.0
TIS 83/ *0138*	17.7
CN 1448-59	16.9
TIB-4	15.1
VSP-4	13.7
Jewel 440031	13.6
440203	13.5
Camote Rosita	13.1
Nemanete	12.9
Kandee	12.3
Salyboro	12.3
NC-1560	12.0
Tainung No 64	11.5
440443	11.1
SPK 004	11.0
199062.1	11.0
199005.11	10.5
Comensal	10.3
BP-SP-2	10.2
Excel 440016	8.3
Apomuden	6.9
Jewel 566638	6.5
Test statistics	
N	25
Chi square	29.269
Df	24
Assump. Sig.	0.21

cooking time compared to the other varieties. The generally low scores recorded for the stickiness of the boiled roots could be considered as reflecting a lesser preference for the stickiness level. The significant differences (P< 0.05) among the boiled roots for all the parameters studied could also be attributed to varietal differences, inherent differences in starch content, composition, as well as the levels of soluble and insoluble fibres.

The panellist's assessment of the boiled sweet potato roots reveals the potential of several varieties to serve as an important ingredient in local food preparations. Missah et al. (1993) found that sweet potato roots are consumed in several forms in Ghana, and these include, "ampesi" (boiled) with or without stew, and "oto" (boiled and mashed roots with pepper, onions, and tomato). *Beauregard* 566613, with its highly preferred appearance and texture could be used in the preparation of "ampesi" and "oto". Similarly, *TIS 83/0138, VSP* 4 and *CN* 1448-59 could be considered as important ingredients for snack products while others like *Excel* 440016 could be exploited as an ingredient for *fufu* due to their unique attributes with respect to taste.

Friedman's test analysis of the panellists' assessment of the boiled roots however showed *Xushu* 18 as the best preferred variety, followed by *TIS* 2534 and *Beauregard* 566613 with *Jewel* 566638 ranking as the least (Table 4). Van de Fliert et al. (2000), reported that in Vietnam, sweet potato is favoured because of its high productivity and low management and input requirement, which makes it an easy and potentially profitable enterprise. Communities in Uganda have also demonstrated the potential of sweet potato in reducing rural poverty; as housewives are not only giving their families daily portions of vitamin A-rich orange-fleshed sweet potato, but are also earning a living from the sale of roots and Thus the incorporation of sweet potato into local food preparations will increase its potential as a cash crop in Ghana.

Sensory evaluation of fried roots

The results of fried roots presented in Table 5 indicated that *Beauregard* 566613 was the preferred variety; while *440203* and *CN* 1448-59 were less preferred in terms of appearance. Zuraida (2003) reported that frying of sweet potato enhances its sweetness. Seven varieties were preferred for their taste with *Jewel 440031* being the most preferred. Alkpokpodlon et al. (2001) reported that for sweet potato cultivars, a parameter such as taste dictates a consumer's preference for a particular cultivar. This is shown by the significant differences in taste (p< 0.05) observed among the sweet potato varieties. Zuraida (2003) also reported that good eating quality plays an important role in the selection of sweet potato varieties and the most preferred variety is usually characterized by good taste after steaming, baking or frying.

Texture assessment was aimed at determining the fibrous nature of the sweet potatoes when pressed between the fingers. Four varieties, *Nemanete, Jewel* 566638, *TIS* 2534 and *SPK 004* were preferred genotypes for their texture, while *BP-SP*-2 was the least preferred. Generally, the stickiness and softness of the fried roots were less preferred by the panellists. The significant differences (P < 0.05) in stickiness and softness recorded among the fried roots could be attributed to varietal differences.

Friedman test analysis on the panellist's assessment of the fried roots showed *SPK 004* as the best preferred variety, followed by *VSP 4* and *Beauregard* 566613 (Table 6). The adoption of such varieties in local food preparations such as "koliko" or "chips" will therefore be a major step in the quest to increase food security and improve the income levels of people especially those in rural communities where sweet potato is grown. Processed rich orange-fleshed sweet potato (CIP, 2004).

Conclusion

The fresh sweet potato leaves generally constitute a richer

Table 5. Sensory scores for fried roots of sweet potato genotypes.

Variety	Sensory attribute				
	Appearance	Taste	Texture	Stickiness	Softness
Beauregard 566613	5.0	4.2	3.6	3.8	2.2
Xushu 18	3.4	2.6	4.0	4.0	3.0
Salyboro	3.8	4.0	4.0	3.0	8.2
Apomuden	4.4	3.4	3.4	3.0	1.4
TIS 83/ 0138	4.0	3.6	3.0	3.6	4.0
TIB-4	4.6	4.4	3.6	2.6	2.4
Excel 440016	3.0	3.4	3.6	2.4	1.6
BP-SP-2	3.4	2.4	2.0	2.0	2.0
NC-1560	4.6	4.0	4.0	1.0	1.4
440443	3.4	3.2	4.4	1.6	1.6
Nemanete	3.4	3.4	4.6	1.6	3.0
Jewel 566638	4.0	2.4	4.6	2.0	1.6
Camote Rosita	3.0	3.6	3.0	2.0	3.2
Tainung No 64	4.0	3.4	3.4	2.4	2.0
Jewel 440031	4.6	4.6	4.4	3.0	2.0
TIS 2534	3.6	3.6	4.6	3.4	3.6
VSP 4	4.4	4.0	5.0	2.4	3.4
Resisto	4.2	3.2	4.2	2.8	3.0
199062.1	4.6	2.6	3.6	3.6	2.6
440203	2.6	3.6	3.6	2.6	3.4
Kandee	3.6	4.0	3.0	2.6	3.2
CN 1448-59	2.6	3.6	4.4	3.0	2.0
199005.11	3.6	3.0	3.4	3.4	1.6
SPK 004	4.6	3.6	4.6	4.0	2.6
Comensal	4.4	3.6	4.2	2.4	2.6
p	0.00	0.00	0.00	0.00	0.00

Table 6. Friedman test ranking of fried roots.

Variety	Mean rank	Variety	Mean rank
SPK 004	19.6	*TIB*-4	16.0
VSP-4	18.9	*Salyboro*	15.8
Beauregard 566613	18.4	*TIS* 83/ *0138*	15.7
Jewel 440031	18.2	*Comensal*	14.4
TIS 2534	17.2	199062.1	14.2
Resisto	14.2	*Apomuden*	10.3
Xushu 18	13.3	*Jewel* 566638	9.5
Kandee	13.2	*Camote Rosita*	9.4
440203	12.2	*Tainung* No 64	9.3
CN 1448-59	12.1	199005.11	9.0
NC-1560	11.8	440443	7.8
Nemanete	12.3	*Excel* 440016	7.2
		BP-SP-2	4.5
Test statistics			
N	25		
Chi square	36.672		
Df	24		
Assump. sig.	0.047		

source of provitamin A carotenoid compared to the fresh roots. Varieties with high provitamin A carotenoid in leaves have low contents in roots and vice versa. -carotene was the most dominant provitamin A carotenoid in both the leaves and roots of the sweet potato varieties. Several sweet potato varieties including *Beauregard* 566613, *Jewel* 440031, and *Camote Rosita* had higher levels of provitamin A carotenoid (-carotene) than *Apomuden*, the locally grown orange-fleshed variety.

Xushu 18 was the best preferred variety, followed by TIS 2534 and *Beauregard* 566613 in the farmer's assessment of the sensory attributes of the boiled sweet potato roots. For the fried samples *SPK* 004 was identified as the best preferred variety, followed by *VSP* 4 and *Beauregard* 566613.

The results obtained present a unique opportunity with regards to the introduction and selection of the new sweet potato varieties; as the potential of these varieties could be exploited based on the carotenoid levels in the leaves or roots. Varieties which have high total carote-noid in their leaves could be introduced in communities where leafy vegetable consumption is relatively popular, while those with high carotenoid in the roots could be used to target communities where the roots are much used as a staple.

Sweet potato varieties such as *Beauregard* 566613, *Jewel* 440031 and *Camote Rosita* with higher levels of -carotene in their roots and leaves are good potential candidates for a food-based approach to solving the vitamin A deficiency in many communities in Ghana. It can be used in complimentary approaches to solving vitamin A deficiency with other interventions such as vitamin A capsules pursued by the government.

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