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Nutrient variation in colored varieties of *Ipomea batatas* grown in Vihiga County, Western Kenya

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Abstract

Nutrient deficiencies are a major global health problem affecting more than 2 billion people (children included) in low income countries. Deficiencies are reported for both organic nutrients such as vitamin C, beta-carotene (BC)-the vitamin A (VA) precursor and for mineral nutrients; calcium (Ca), iron (Fe) and potassium (K). In Kenya, potential nutrient-rich foods such as *Ipomea batatas* (sweet potato) are locally available but their nutrient content needs to be quantified. Vihiga County, Kenya grows white, yellow, purple and orange colored flesh sweet potato varieties. This study aimed at quantifying vitamin VA and C in raw and boiled varieties of sweet potato from Vihiga County. In addition, raw samples of sweet potato as well as soils growing them were quantified for Ca, Fe, K and copper (Cu). Liquid chromatography, iodometric titration and atomic absorption spectroscopy were employed. The orange fleshed varieties had significantly higher level of Fe, K, Cu and vitamins. Vitamins though reduced significantly with boiling. The level of Ca, Fe, K and Cu in soils was positively correlated (r=0.07) with those found in the sweet potato. This study indicates that the orange fleshed sweet potato contain higher levels of Fe, Cu, K, VA and vitamin C making it a very rich source for both organic and mineral dietary nutrient. While production of other sweet potato varieties is encouraged, the study findings promote the consumption of orange fleshed sweet potato to address nutrient deficiencies.

Introduction

Deficiencies of nutrients are still a major global health problem with more than 2 billion people mostly in low income countries estimated to be deficient (World Health Report 2004). Deficiencies are reported for organic nutrients such as vitamin C and beta-carotene (BC) which is a vitamin A (VA) precursor. Also reported are deficiencies in mineral nutrients including calcium (Ca), iron (Fe) and potassium (K). These deficiencies increase the general risk of both infectious and non-communicable illnesses (such as vitamin A deficiency) and dying from diarrhea, measles, malaria and pneumonia (World Health Report 2004). Pregnant women, lactating women and young children, are most vulnerable mainly because they have a relatively greater need for vitamins and minerals (Nabakwe and Ngare, 2004; Ministry of Health, 2010). Children in particular have an increased risk of vitamin A deficiency which is globally a leading cause of disease burden and mortality. Deficiencies have been pegged to lack of access to nutrient-rich foods such as fruits, vegetables, animal products and forti¬fied foods partially due to their being expensive or are locally unavailable. The importance of food based approaches for the prevention and control of nutrient deficiencies as well as for the improvement of nutrient in general is fully recognized worldwide (FAO, 2005; Musinguzi *et al*., 2006; Nawiri *et al*., 2012).

Sweet potato (*Ipomoea batatas* (L) Lam) belongs to the botanical family Convolvulaceae. It is amongst the world's most important, versatile and under-exploited food crops with more than 133 million tones in annual production. It ranks the fifth most important food crop on a fresh weight basis in developing countries after rice, wheat, maize and cassava and cultivated in over 100 developing countries (CIP, 1999). While the tuber is consumed as a staple food, other roles are reported and as well other parts of the crop have been found to be important. Other than being combined with lime juice to make dye for clothes, sweet potatoes have also been used as fodder for animals and as green vegetables (Woolfe, 1992; Abidin, 2004). The skin colors of sweet potatoes range from white, cream, yellow, orange, pink, red

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to purple. Flesh colors may be white or various shade of cream, yellow, orange or even purple (Purseglove, 1991; Woolfe, 1992; Abidin, 2004; Abubakar *et al*., 2010).

The desirable nutritional value of *Ipomoea batatas* is gaining recognition, as the understanding between diet and health increases. Various parts of the crop have been reported to contain both organic and mineral nutrients including vitamins A and C, zinc, potassium (K), sodium, manganese, calcium (Ca), magnesium (Mg) and iron (Fe) (Woolfe, 1992; Antia *et al*., 2006; Leighton, 2007; Oduro *et al*., 2008; Ofori *et al*., 2009; Abubakar *et al*., 2010; Meludu, 2010; Ingabire and Vasanthakaalam, 2011; Ukom *et al*., 2011; Hue *et al*., 2012). According to Woolfe, (1992) potassium is the major mineral in sweet potatoes followed by phosphorous (P), Ca, Mg, Fe, and copper (Cu).

The nutrient content in plants vary depending on differences in soil mineral content, interaction between minerals, varieties and processing (Landon, 1991; Woolfe, 1992; Ravindran *et al*., 1995; Kruger *et al*., 1998; Chattopadhyay *et al*., 2006; Leighton, 2007; Abubakar *et al*., 2010; Sunette, 2010; Ingabire and Vasanthakaalam 2011; Ukom *et al*., 2011). Okum and co-workers (2009) found a significant increase in the mineral contents of most sweet potato varieties with application of nitrogen fertilizer. Toxicity of Cu in plants is rare but soil concentrations above 100 mg/kg are regarded as high and as well a range of 0.19-0.50 mg/100g in sweet potatoes has been reported (Woolfe, 1992; Kruger *et al*., 1998). Potassium though is readily available in the soil solution for uptake by plant roots. Calcium is very important in plant growth and is not considered toxic to plants but high levels of Fe and especially K may reduce its uptake in crops. Studies report Ca in sweet potatoes to vary in the range of 7-85 mg/100g while level of Fe varies between 0.16-2.11 mg/100 g (Woolfe, 1992; Abubakar *et al*., 2010; Sunette, 2010). The white and cream fleshed sweet potatoes have been found to virtually contain no BC while the range in colored fleshed varieties is less than 100 μg to more than 26600 μg/100 g (Laurie, 2001; Van Jaarsveld *et al*., 2005; Van Jaarsveld *et al*., 2006). However, the retention of BC and vitamin C decreases due to either boiling, sun drying or storage (Van Jaarsveld *et al*., 2006; Bengtssonet *et al*., 2008; Bechoff *et al*., 2009; Nawiri *et al*., 2012).

Vihiga County, one of the most densely populated areas in western Kenya lies between longitudes 34º 30´ and 35º 0´ East and between latitudes 0º and 0º 15´ North, with four districts Emuhaya, Vihiga, Hamisi and Sabatia. The region receives an annual rainfall ranging from 1740-1940mm with average temperature ranging from 14-34ºC in January and 14-30ºC in July (District Strategic Plan, 2005). Orange, purple, white and yellow fleshed varieties of sweet potatoes are grown throughout the year in this county but high prevalence of nutrient related diseases have also been reported (Akelola *et al*., 2007). While the desirable nutritional qualities will place sweet potato in a unique position in the quest to eliminate nutrition deficiencies in communities of Vihiga County, literature on the nutrient content of the sweet potatoes is scarce.

Materials and Methods

Sampling and sample pretreatment

Three farmers were identified in each of the four districts of Vihiga county; Emuhaya, Vihiga, Hamisi and Sabatia. Under regular practice of planting sweet potatoes (without use of fertilizer) each farmer planted the white, yellow, orange and purple varieties of sweet potatoes in their regular farms (experimental plots of 3m by 3m size). About 200 grams of each variety was randomly sampled thrice after 90 days of growth at intervals of 10 days upto 120 days, as per the regular farmer's practice of harvest (Woolfe, 1992). The different varieties of sweet potatoes were packed in separate paper bags and transported to the laboratory where they were washed to remove soil debris. The outer cover was peeled off before being cut into small pieces and samples of the same colored variety obtained during the three sampling sessions were homogenized for analysis. Samples to be analyzed in their raw form for mineral nutrients were dried at 70ºC for 24 h to achieve moisture content of less than 10 before digestion. Else they were boiled at 30ºC for 15 min before storage. Samples for analysis of vitamin A and C in the raw form were stored fresh at -4ºC.

Concurrently during sweet potatoes sampling, 500 g of soil was randomly sampled from each plot and packed in separate paper bags for transportation to the laboratory where they were dried at 70ºC for 24 h to achieve a moisture content of less than 10 before digestion. However, soil characterization was not within the scope of this study.

Chemicals

Potassium hydroxide (KOH), sodium sulphite, soluble starch, potassium iodate salt, potassium iodide copper nitrate, iron (II) nitrate, butylated hydroxytoluene (BHT), potassium chloride, all-trans-BC (Type IV), vitamin C solid, calcium carbonate, lanthanum chloride were sourced from Sigma-Aldrich and supplied by Kobian chemicals, the local distributor. All other chemicals used were of analytical grade.

Sample digestion and measurement of mineral nutrients

Standard procedures were followed according to Ukom *et al*. (2011). Briefly, about 10 g (in triplicates) of dried sweet potato was ground in a mortar and sieved through a 0.2 mm pore size sieve. 1.0 g of the fine powder was wet digested with ultra pure nitric acid and digested for 10 min at 120^{0}C while adding few drops of hydrogen peroxide. The solution was then filtered and diluted with deionised water before aspiration into the spectrophotometer. Triplicates soil samples were also subjected to similar treatment.

Atomic Absorption spectrophotomete r(model Buck scientific 210 VGP) was used for the measurement of Cu, Fe and Ca while Flame photometry (model Sherwood 410) was used for analysis of K. The operating parameters were set according to the specification given by the manufacturer including lamp current of 1.2 amperes and fuel system of air/acetylene. Instrumental calibration was done with blanks and the following ranges of working standards; 1.0-5.0 ppm Ca, 0.1-0.5 ppm Cu, 0.5-2.5 ppm Fe and 2-20 ppm K. The equation of each generated calibration curve was used in calculating analyte concentrations in the soils and sweet potato samples.

Extraction and measurement of vitamins

Beta carotene extraction procedure was modified according to Nawiri *et al*. (2012). Briefly, Sweet potatoes samples previously stored at -4ºC were let to thaw then 3 g were mashed in a mortar. To this was added 50 mL of 0.5M ethanolic potassium hydroxide, 5.0 mL of 10% sodium sulphite solution (w/v) and 0.3 g of ascorbic acid. n-hexane was added to the mixture, shaken thoroughly and allowed to settle before decanting the hexane layer into a separating funnel. The residue was re-extracted four times and the combined extracts were washed with 1.0M KOH, followed by equal portions of distilled water until decolorized. Hexane was dried by filtering over anhydrous sodium sulphate and evaporated at 40ºC in a rotatory evaporator to almost dryness while breaking the vacuum with nitrogen gas. The residue was then re-dissolved in 5ml of ethanol, filtered through a 0.45 µm millipore and stored at -4ºC before injection into the high performance liquid chromatography (HPLC) column.

The HPLC equipment (Shimadzu-SCI 10A KD-600) was calibrated using freshly prepared BC (standards calibration range 2-10 ppm) with the absorbance set at 450 nm. Sample extracts were checked for the UV-Vis maximum absorbance before injection into the HPLC column to avoid column overloading. Sample extracts (20 µl) were injected into the column through a 20 µl injection loops using a micro-syringe (injector syringe model, Hamilton injection syringe 1750 GASTIGHT). Separation was performed isocratically with a degassed mobile phase consisting of methanol/DCM/water in the ratio 80:18:2 (v:v:v) containing 0.1% BHT on a C_{18} column(250 X 4..6 mm id, 5 µm particle size, Vydac TP-201) with absorbance units set between 0.4AU-1.2AU. The elution took 8 minutes at a flow rate of 1.0 mL/min. Beta-carotene was monitored using a UV-Vis detector (tungsten lamp) at 450nm at sensitivity of 0.0500 absorbance unit's full scale. All trans-BC was identified by comparing the retention times with that of standard solutions while peak areas were used for quantification.

For vitamin C analysis, 10ml of distilled water was added to 10g of a sweet potatoes sample and mashed in a mortar. The extract was decanted and the process repeated twice. The sample extract was strained through a cheese cloth rinsing the pulp with distilled water into a 100 mL volumetric flask and topping up to the mark using distilled water. The extract was titrated with standardized iodine solution.

Data analysis

Data were analyzed with SPSS 17.0 for windows. The mean and standard deviation of means were calculated. The data were analyzed by one-way analysis of variance (ANOVA) and Duncan's multiple range tests was used to separate means ($P < 0.05$).

Results and Discussion

Mineral nutrients in soils

The content of copper (Cu), iron (Fe), potassium (K) and calcium (Ca) in soils from four districts in Vihiga county are presented in Table 1. The levels of mineral nutrients in the soils from all districts decreased in the order Fe>K>Ca>Cu. Copper levels ranged between 1.25 mg/100g and 1.53 mg/100g in the county with the soils in Sabatia having significantly higher level than the other three districts (p=0.000). The findings however, indicate safe levels of Cu in the soils of vihiga county (Landon, 1991). Iron levels in soil were found to be high with a range between 564.45 mg/100g and 741.33 mg/100g with Hamisi district recording significantly higher levels than the other districts (p=0.000). Potassium levels in soil ranged between 73.90-100.50 mg/100g being significantly high in Hamisi district (p=0.000). Levels

Table 1. Mean mineral nutrients (mg/100g) in soils growing sweet potatoes in districts of Vihiga County (Mean ± sd)[1,2]

Element	Site	mean±sd (range)	P-value
Copper	Sabatia	1.525 ± 0.01^{d}(1.5-1.53)	
	Hamisi	1.25 ± 0.01^{b}(1.25-1.28)	
	Emuhaya	1.375 ± 0.01^{c}(1.35-1.40)	
	Vihiga	0.85 ± 0.01^{a}(0.83-0.88)	0.000
Iron	Sabatia	247.85 ± 2.60^{b}(244.88-249.69)	
	Hamisi	296.53 ± 3.23^{d}(292.87-298.98)	
	Emuhaya	285.29 ± 1.53^{c}(283.98-286.98)	
	Vihiga	225.78 ± 2.26^{a}(223.46-227.98)	0.000
Potassium	Sabatia	73.9 ± 1.00^{a}(71.25-76.25)	
	Hamisi	100.5 ± 0.13^{d}(99.68-100.25)	
	Emuhaya	91.05 ± 2.60^{b}(83.98-96.75)	
	Vihiga	93.68 ± 1.75^{c}(90.00-98.50)	0.000
Calcium	Sabatia	34.70 ± 0.20^{b}(34.13-35.00)	
	Hamisi	35.43 ± 0.34^{c}(34.45-35.98)	
	Emuhaya	30.68 ± 0.32^{a}(30.00-31.58)	
	Vihiga	39.58 ± 0.18^{d}(39.25-40.00)	0.000

[1]Range in parenthesis
[2]Same small letters for a specific element in the column are not significantly different (p<0.005); W-white, P-purple, Y-yellow, O-orange

of K are attributed to the readily available K found in soil solution. For Ca, significantly higher levels were recorded in Vihiga district as compared to the other districts (p=0.000). The Ca levels in the county are however possibly reduced by the high levels of other cations such as Fe and K which are also known to reduce its uptake in crops.

Mineral content in sweet potatoes

The content of copper (Cu), iron (Fe), potassium (K) and calcium (Ca) in the white, purple, orange and yellow varieties of sweet potatoes from the four districts of Vihiga county are presented in Table 2. Generally the levels of mineral nutrients in sweet potatoes from the districts decreased in the order Ca>K>Fe>Cu indicating a linear positive correlation (r>0.700) between the mineral nutrients in sweet potato and in the soils. These findings are in line with the work of previous authors (Woolfe, 1992; Antia *et al*., 2006; Ukom *et al*., 2011).

The content of Cu in varieties of sweet potatoes ranged between 0.25-0.65 mg/100g within the county. Toxicity of Cu rarely occur naturally in soils and this range of Cu in Vihiga was described as safe (Landon, 1991). In nutrition however, Cu works with Fe in the formation of red blood cells as well as keeps the blood vessels, nerves, immune system, and bones healthy. Although Antia and co-workers (2006) report that Cu was completely absent in sweet potatoes leaves, our findings are within ranges of other studies (Woolfe, 1992; Kruger *et al*., 1998). The orange fleshed sweet potatoes had significantly higher Cu content irrespective of the district they were grown (p<0.005). In comparison to other colored varieties of sweet potatoes, this variety has generally higher levels of nutrients (Laurie, 2001; Van Jaarsveld *et al*., 2006).

The Fe content in sweet potatoes ranged between 1.03-1.4 mg/100g in the county this being attributed to the high levels of Fe in the soil from Vihiga county (Table 1). While the levels found in this study are in agreement with earlier findings, higher levels of Fe in sweet potatoes have also been reported attributed to differences in soil mineral content, interaction between minerals and varieties (Woolfe, 1992; Kruger *et al*., 1998; Abubakar *et al*., 2010; Meludu, 2010; Sunette, 2010; Ingabire and Vasanthakaalam 2011; Ukom *et al*., 2011). The potential benefits of the orange fleshed variety is also observed here as the findings show that at its Fe content was higher in comparison to the other varieties.

The K content in varieties of sweet potatoes in the county ranged between 10.4-168.38 mg/100g. Studies have reported levels of K that are above 129 mg/100g in sweet potatoes attributing that to application of fertilizers (Woolfe, 1992; Ravindran *et al*., 1995; Ukom *et al*., 2011). However, no fertilizer was applied to plots growing the sweet potatoes plots in this study. It's worth noting that for K, the orange fleshed variety grown in all districts also had significantly higher content (p<0.005) in comparison to other varieties.

Calcium content in varieties of sweet potatoes in Vihiga County ranged between 18.50-27.35 mg/100g probably being lower due to the high levels of Fe and K which reduce the Ca uptake in crops. Although the levels found in this study are either higher or lower than previous studies, Ca is not known to be toxic to plants (Woolfe, 1992; Ravindran *et al*., 1995; Sunette, 2010). Contrary to Cu, Fe and K being highest in the orange variety, different varieties were found to contain higher Ca in Vihiga County. The yellow fleshed variety grown in Sabatia and Hamisi and the white variety grown in Emuhaya had significantly higher Ca (p<0.000). While the reason may not be explained within the scope of this study, this could be attributed to factors mentioned that cause differences in nutrient content of plants (Woolfe, 1992; Ravindran *et al*., 1995; Kruger *et al*., 1998; Leighton, 2007; Abubakar *et al*., 2010; Meludu, 2010; Sunette, 2010; Ingabire and Vasanthakaalam 2011; Ukom *et al*., 2011).

Table 2. Mean (n=3) of mineral nutrients (mg/100g) in varieties of sweet potatoes grown in districts of Vihiga County (Mean ± sd)[1,2]

		Districts in Vihiga county							
		SABATIA		**HAMISI**		**EMUHAYA**		**VIHIGA**	
	SPV	**Mean ± sd[1]**	**P-value**	**Mean ± sd[1]**	**P-value**	**Mean ± sd[1]**	**P-value**	**Mean ± sd[1]**	**P-value**
Cu	W	0.45±0.01^{b}(0.43-0.48)	0.003	0.35±0.02^{b}(0.3-0.38)	0.000	0.33±0.02^{a}(0.30-0.38)	0.000	0.25±0.01^{a}(0.33-0.39)	0.000
	P	0.35±0.0^{a} (0.30-0.38)		0.53±0.02^{c}(0.5-0.58)		0.45±0.01^{b}(0.43-0.48)		0.45±0.01^{b}(0.43-0.48)	
	Y	0.45±0.01^{b}(0.43-0.48)		0.28±0.01^{a}(0.25-0.3)		0.38±0.01^{a}(0.35-0.40)		0.48±0.01^{b}(0.45-0.50)	
	O	0.50±0.02^{b}(0.45-0.53)		0.65±0.01^{d}(0.65-0.68)		0.60±0.01^{c}(0.58-0.60)		0.55±0.01^{c}(0.53-0.58)	
Fe	W	1.30±0.01^{b}(1.28-1.33)	0.001	1.30±0.01^{a}(1.275-1.33)	0.004	1.28±0.02(1.23-1.33)	0.870	1.10±0.02^{a}(1.08-1.15)	0.000
	P	1.28±0.02^{b}(1.23-1.33)		1.28±0.01^{a}(1.25-1.30)		1.30±0.01(1.28-1.33)		1.30±0.02^{b}(1.25-1.33)	
	Y	1.12±0.02^{a}(1.08-0.18)		1.28±0.02^{a}(1.25-1.33)		1.28±0.02(1.23-1.33)		1.03±0.02^{a}(1.00-1.08)	
	O	1.38±0.02^{b}(1.33-1.40)		1.40±0.02^{b}(1.38-1.43)		1.28±0.02(1.25-1.33)		1.33±0.02^{b}(1.28-1.35)	
K	W	10.40±0.20^{a}(9.98-10.95)	0.000	14.66±1.04^{a}(10.88-16.05)	0.000	16.50±0.38^{a}(16.25-17.50)	0.000	8.38±0.13^{a}(8.03-8.65)	0.000
	P	16.43±0.32^{c}(15.88-17.33)		18.25±0.54^{b}(17.48-19.88)		13.25±0.55^{a}(12.43-14.85)		13.70±0.34^{b}(13.08-14.68)	
	Y	13.43±0.27^{b}(12.83-14.18)		14.25±0.15^{a}(14.0-14.675)		16.38±0.48^{a}(15.0-17.23)		14.60±0.23^{b}(13.93-15.00)	
	O	131.78±1.09^{d})(129.0-134.45)		136.98±1.22^{d}(134.95-137.5)		168.38±2.10^{b}(162.45-172.50)		149.85±1.78^{c}(144.95-153.63)	
Ca	W	25.88±0.37^{b}(24.93-26.75)	0.001	25.30±0.23^{c}(24.63-25.63)	0.000	26.30±0.11^{c}(26.0-26.48)	0.000	25.93±0.52^{b}(24.93-27.40)	0.001
	P	24.43±0.03^{a}(24.35-24.50)		18.50±0.22^{a}(17.88-18.93)		23.70±0.43^{b}(22.45-24.35)		24.13±0.14^{b}(23.85-24.50)	
	Y	27.35±0.02^{c}(27.32-27.35)		26.30±0.01^{d}(26.28-26.33)		24.75±0.10^{b}(24.48-24.98)		25.78±0.57^{b}(24.73-27.38)	
	O	24.31±0.31^{a}(23.63-25.00)		22.00±0.25^{b}(21.4-22.65)		22.02±0.23^{a}(21.25-22.50)		21.28±0.07^{a}(21.08-21.40)	

[1]Range in parenthesis
[2]Same small letters for a specific element in the column are not significantly different (p<0.005); W-white, P-purple, Y-yellow, O-orange

Table 3. Mean content of beta-carotene (µg/100g) and vitamin C (mg/100g) in raw and boiled varieties of sweet potatoes grown in districts of Vihiga County (Mean ± sd)[1,2]

		Beta-carotene (raw)		**Beta-carotene(boiled)**	**Vitamin C (raw)**		**Vitamin C (boiled)**	
Districts	Variety	Mean±sd	p-value	Mean±sd	**mean±sd**	**p-value**	**mean±sd**	**P-value**
Sabatia	W	ND		ND	4.85±0.00^{a}(4.82-4.87)		0.81±0.13(0.82-0.81)	
	P	ND		ND	5.51±0.00^{b}(5.51-5.51)		0.88±0.01(0.88-0.88)	
	Y	2628±2.50^{a}(2590-2684)	0.003	ND	5.51±0.00^{b}(5.51-5.51)		0.81±0.13(0.81-0.82)	
	O	4853±2.63^{b}(4660-5153)		ND	5.51±0.38^{b}(5.50-5.53)	0.0049	0.88±0.01(0.88-0.88)	0.596
Hamisi	W	ND		ND	4.85±0.00^{a}(4.85-4.85)		0.88±0.01(0.88-0.88)	
	P	ND		ND	5.30±0.13^{b}(5.29-5.31)		0.81±0.13(0.81-0.82)	
	Y	2452±2.54^{a}(2391-2562)	0.004	ND	5.58±0.13^{b}(5.57-5.59)		0.88±0.01(0.88-0.88)	
	O	4778±1.78^{b}(4572-4927)		ND	5.58±0.13^{b}(5.57-5.59)	0.000	0.88±0.00(0.88-0.88)	0.441
Emuhaya	W	ND		ND	4.85±0.01^{a}(4.85-4.85)		0.81±0.13(0.81-0.82)	
	P	ND		ND	5.36±0.13^{a}(5.35-5.37)		0.88±0.01(0.88-0.88)	
	Y	2267±1.46^{a}(2201-2352)	0.002	ND	5.58±0.13^{b}(5.57-5.59)		0.81±0.13(0.81-0.82)	
	O	4889±2.56^{b}(4590-5087)		ND	5.73±0.01^{a}(5.73-5.73)	0.000	0.73±0.13(0.72-0.73)	0.487
Vihiga	W	ND		ND	4.85±0.01^{a}(4.85-4.85)		0.88±0.01(0.88-0.88)	
	P	ND		ND	5.51±0.01^{b}(5.51-5.51)		0.88±0.01(0.88-0.88)	
	Y	2071±2.47^{a}(1909-2163)	0.004	ND	5.51±0.01(5.51-5.51)		0.88±0.01(0.88-0.88)	
	O	4619±2.74^{b}(4632-5198)		ND	5.66±0.13(5.65-5.67)	0.000	0.88±0.01(0.88-0.88)	-

[1]Range in parenthesis
[2]Same small letters for a specific element in the column are not significantly different (p<0.005); W-white, P-purple, Y-yellow, O-orange

Beta-carotene and vitamin C in sweet potatoes

The content of BC (the precursor for VA) and vitamin C in the four varieties of sweet potatoes grown in Vihiga County are presented in Table 3. In raw sweet potatoes, BC was detected in the yellow and orange fleshed varieties only therefore supporting studies that found virtually no beta-carotene in white fleshed varieties (Van Jaarsveld *et al*., 2005; Ingabire and Vasanthakaalam, 2011). In the county, the range of BC was 4619- 4889 µg/100g in the orange variety being significantly higher than 2017-2628 µg/100g of the yellow fleshed variety (p<0.005). The findings support previous studies on the significant role of orange fleshed sweet potatoes to be utilized as a viable food-based strategy for controlling vitamin A deficiency (Laurie, 2001; Van Jaarsveld *et al*., 2006). Boiling however, resulted in losses of BC (Table 3). Beta-carotene is known to be susceptible to degradation upon exposure to heat, light and oxygen (Van Jaarsveld *et al*., 2006; Bengtsson *et al*., 2008; Nawiri *et al*., 2012).

The sweet potatoes varieties in Vihiga county contained vitamin C in the range 4.85 mg/100 g to 5.73 mg/100g but boiling significantly reduced this to about 0.88 mg/100 g. Various processing procedures including baking, frying and boiling are attributed to degradation of this vitamin (Lee and Kader, 2000; K'Babalola *et al*., 2010). The raw orange fleshed variety had significantly higher (p<0.005) content of vitamin C than the other varieties indicating its potential to provide for this vitamin.

Conclusion

This study indicates that the orange fleshed sweet potatoes contain high levels of Fe, Cu, K, VA and vitamin C making it a very rich source for both organic and mineral dietary nutrients. However, the other varieties can contribute to nutrient requirements of children and are strongly recommended.

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