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Nutrient Composition of Selected Sweet Potato [*Ipomea batatas (L) Lam*] Varieties as Influenced by Different Levels of Nitrogen Fertilizer Application

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Abstract: Total ß-carotene content of four varieties of Sweet potatoes [*Ipomoea batatas* (*L*) *Lam*] as influenced by different levels of nitrogen fertilizer were determined by High Performance Liquid Chromatography (HPLC) The proximate composition and mineral contents were also determined. The nitrogen fertilizer treatments were combinations of four levels of 0kgN/ha(control), 40 kgN/ha, 80 kg/Nha, 120 kgN/ha on the four varieties of Sweet potato; white-fleshed TIS87/0087 and TIS8164, orange-fleshed Ex-Igbariam and CIP Tanzania. Nitrogen fertilizer significantly ($p<0.05$) increased the total ß-carotene and crude protein with increase in nitrogen fertilizer application up to 120 kgN/ha. Generally there was a trend in the total ß-carotene increase from 0-80 kgN/ha for all the varieties except CIP Tanzania which showed no such trend. On the average, TIS87/0087 and Ex-Igbariam varieties gave the highest total ß-carotene content at 40-80 kgN/ha when compared with the control. The highest yield for the crude fiber was observed at the control (0 kgN/ha) for all the varieties except TIS8164 which highest value was observed at 40 kgN/ha. Application of nitrogen above 80 kgN/ha did not increase the yield of most nutrient (namely, ß-carotene and protein). Generally, application of nitrogen fertilizer increased the mineral contents of most Sweet potato varieties significantly ($p<0.05$) from 0-120 kgN/ha with the exception of phosphorus which showed significant decrease. The overall results indicate increased bioavailability of ß-carotene (Provitamin A) and crude protein for good nutrition and health particularly at 40-80 kgN/ha.

Key words: Total ß-carotene, chemical composition, mineral content, nitrogen fertilizer, sweet potato

INTRODUCTION

Sweet potato [*Ipomoea batatas (L) Lam*] is a perennial crop grown as a annual (Woolfe, 1992). It is a root crop that provides food to a large segment of the world population, especially in the tropics where the bulk of the crop are cultivated and consumed (Kocklar, 1981; Opeke, 2006). The International Potato Centre (CIP) holds the largest Sweet potato gene bank in the world with more than 6,500 wild, traditional and improved varieties (Food and Culture Encyclopedia, 2003). According to FAO (2006) statistics, West African Sweet potato production stood at 2.516 million metric tons. Sweet potato is high in nutritive value, outranking most carbohydrate foods in vitamins, minerals, protein and energy content (Watt and Merrill, 1975; Onuh *et al*., 2004). Sweet potato serves as a staple food vegetable (fleshy roots and tender leaves), snack food, weaning food, animal feed, as well as a raw material for industrial starch and alcohol. It is processed into diverse products (Bouwkamp, 1985; Lin *et al*., 1985; Udensi, 2000).

Sweet potato, depending on cultivar is high in carotenoids, particularly, the hydrogen carotenoid, the ß-carotene (Kosambo *et al*., 1998). ß-carotene is a potent provitamin A with 100% activity. The importance of this carotenoid in nutrition and health in the developing countries where deficiency of vitamin A remains a serious health problem cannot be over-emphasized (Rodriguez-Amaya, 1997).

Nitrogen is an important factor in determining the yield and nutrient composition of root tubers, especially Sweet potato. Nitrogen application to Sweet potato was shown to linearly increase dry matter content, carotenoid and protein content of Sweet potato (Constantin *et al*., 1984). Nitrogen also plays a vital role in the plant biochemistry as an essential constituent of cell wall, cytoplasmic proteins, nucleic acid, chlorophyll and other parts of the cell (Hay and Walker, 1989). Villagarcia (1996) found that the response of Sweet potato to nitrogen fertilizer application depends highly on genotypic and environmental variations. Four Sweet potato varieties and four levels of nitrogen fertilizer application were therefore evaluated within Umudike in Southeastern Nigeria agro ecological zone. To compare the nutrient composition of these varieties, analysis of total ß-carotene, proximate and mineral content were performed.

MATERIALS AND METHODS

Field work and experimental design: The study area was Umudike, Ikwuano LGA, Abia State Southeast, Nigeria, located at latitude 05 29 N and longitude 07 33 E and at an elevation of 122 meters above sea level. This soil is classified as sandy loam, acidic and characterized as an ultisol (Eke-Okoro, 2001).

The experimental field was marked and harrowed. A 4*4 factorial Arrangement in a Complete Block Design (RCBD) was used. Sweet potato vine cuttings of 20 cm of each variety were planted at a spacing of 1 cm* 0.3 m. The fertilizer treatment were four levels of nitrogen (0, 40, 80 and 120 kgN/ha) and four varieties of Sweet potato (TIS87/0087, TIS8164, Ex-Igbariam and CIP Tanzania) were used. Nitrogen was applied as urea. Each of the plots had a blanket application of 150 kgK/ha as muriate of potash and 25 kgP/ha as single super phosphate. The fertilizer application were made at the same time, four weeks after planting. Weeding was done once by hand pulling at 6 weeks after planting. The Sweet potato tuber were harvested 16 weeks after planting and was used for the analysis.

Sample preparation: Freshly harvested samples were washed with clean water, peeled, washed and quartered longitudinally. They were sliced to 1 cm thickness and mixed manually. Part of the sample was packaged in aluminium foil, labeled and stored at -80°C for subsequent ß-carotene analysis using HPLC at 450 nm. The remaining part of the sample was dried in a hot air oven (Gallemkamp model OV-440) at a temperature of 60°C for 24 h. The dried sample was milled in attrition mill to obtain fine flour used for chemical analysis.

Carotenoid extraction: The method of Rodriguez-Amaya and Kimura (2004) (Harvest Plus Method) was used. Duplicates of the -80°C frozen and thawed samples were used for the analysis under a UV-filtered white fluorescent lighting to avoid carotenoid oxidation (Howe and Tanumihardjo, 2006). Carotenoids were extracted by grinding about 3 g of each sample in a mortar using pestle with 50 ml of cold acetone and about three (3) gram Hyflosupercel. The residue was filtered in Buchner funnel equipped with filter paper (Whatman # 2 filter paper), Maidstone, England). The residue was returned to the mortar and extraction was repeated using 20 ml of cold acetone until the residue was nearly colourless.
The total extract was transferred to separating funnel (250 ml) containing 20 ml petroleum ether. One liter of distil water was used to wash the organic phase which separated from aqueous phase. The aqueous phase was discarded. Dilute brine solution was used to wash the aqueous phase to break-up any emulsion that may have formed. The brine solution separated from organic phase was discarded. The organic phase was collected through anhydrous sodium sulphate (15 g) into flat bottom flask. Ten (10) ml of the sample extract was concentrated with a rotary evaporator (Buchi Waterbath B-481 Switzerland) and dried under vacuum for reverse-phase HPLC determination of ß-carotene at 450 nm.

ß-Carotene analysis using reverse-phase HPLC: HPLC procedures for ß-carotene analysis in sweet potato was adopted from Howe and Tanumihardjo (2006). The concentrated sample was reconstituted in methanol/dichloroethane mixture (1000 µl, 50:50 v/v) and 10 µl of it injected into the HPLC consisting of a guard column, C30 YMC carotenoids column (4.6* 250 mm, 3 µm), 625 HPLC pump, 717 auto sampler and a 2996 photodiode array detector (Waters Corporation, Milford, M A). Solvent A was 100% methanol and Solvent B was 100% methyl tert-butyl ether. The isocratic elusion was 50% of solvent A and 50% of solvent B at 1 ml/minute for 15 min. ß-carotene eluted at about 8 min. Chromatograms were generated at 450 nm. Identification of ß-carotene was done using standards and with verification of the absorption spectrum.

Chemical analysis: Flour samples were analyzed in duplicates for dry matter, moisture, ash and fiber contents using Pearson (1976), while protein and fat contents were determined by AOAC (1995). The carbohydrate content was calculated by difference. The mineral content was determined by multiple nutrient extractions (wet-acid digestion) method by Novozamsky *et al*., 1983). Sodium and potassium were determined by flame photometric method (A.O.A.C., 1984). Calcium and magnesium were determined by EDTA versanate complexometric titration method while phosphorus was determined by Molybdate yellow method (Onwuka, 2005) using spectrophotometer.

Statistical analysis and calculations: The mean, standard deviation and analysis of variance (ANOVA) of the data obtained from the study were computed using Statistical Package for Social Science (SPSS) version B. Means were separated using least significant difference test (LSD) at $p<0.05$. Analysis of variance (ANOVA) was specifically performed to check for significant difference ($p<0.05$) between means.

RESULTS AND DISCUSSION

Table 1 shows the total ß-carotene of the different sweet potato varieties at different levels of nitrogen fertilizer application. The response of these sweet potato varieties to the different levels of nitrogen fertilizer application with respect to ß-carotene yield shows significant ($p<0.05$) difference for most of the varieties. At zero (0 kgN/ha) level of nitrogen fertilizer application, the values of ß-carotene content of all the varieties of the sweet potato were closely the same. Increase in the application of nitrogen fertilizer from 0-80 kgN/ha increased ß-carotene yield with the highest numerical value of 13.02 µg/g for Ex-Igbariam at 40 kgN/ha, 18.11 µg/g at 80 kgN/ha for TIS87/0087 and 9.77 µg/g for TIS8164 at 80 kgN/ha. This may indicate that nitrogen stimulate carotenoid biosynthesis, thus agreeing with the report of Constantin *et al*. (1984); Hay and Walker (1989) that nitrogen increased carotenoid and protein

Table 1: Effect of Nitrogen Fertilizer application (kgN/ha) on ß-Carotene Content of Various Varieties of Sweet Potatoes

	0	40	80	120	LSD
CIP Tanzania	6.02^{b}± 0.37	3.02^{d}± 0.03	4.62^{c}±0.16	7.26^{a}± 0.34	0.728
Ex-Igbariam	7.08^{a} ±0.42	13.02^{a}± 0.18	12.69^{a}±2.74	8.50^{a}±3.78	6.504
TIS87/0087	6.67^{d}±0.10	13.33^{b}±0.91	18.11^{a}±1.12	8.96^{c}±0.33	2.058
TIS8164	7.05^{b}±1.16	8.28^{ab}±0.15	9.77^{a}±0.77	2.28^{c}±0.14	1.954

Means with the same superscript in the same row are not significantly different (p>0.05)

Table 2: Effect of Nitrogen concentration on the proximate composition of each sweet potato variety

		Nitrogen concentration (KgN/ha)				
Proximate comp.	Variety	0	40	80	120	LSD
Dry matter	CIP-Tanzania	37.0^{a} ±1.41	36.00^{a}±1.41	34.00^{a}±4.24	35.00^{a}±2.24	8.778
	Ex-Igbariam	37.00^{a} ±2.83	39.00^{a}±2.83	35.00^{a}±4.24	31.00^{a}±1.41	8.328
	TIS 87/0087	30.00^{b}±0.00	33.00^{a}±1.14	34.00^{a}±1.41	31.00^{a}±4.24	6.510
	TIS 8164	39.00^{a} ±1.41	35.00^{a}±7.07	36.00^{a}±4.24	33.00^{a}±1.41	11.778
Moisture Content	CIP-Tanzania	63.0^{a} ±2.83	64.00^{ab}±1.41	66.00^{a}±2.83	65.00^{a}±1.14	6.207
	Ex-Igbariam	63.0^{a} ±2.83	61.00^{a}±1.41	67.00^{a}±4.24	69.00^{a}±2.83	8.328
	TIS 87/0087	70.0^{a} ±7.07	67.00^{a}±2.83	66.00^{a}±2.83	69.00^{a}±4.24	12.712
	TIS 8164	61.00^{a} ±2.24	65.00^{ab}±0.00	64.00^{a}0.00	67.00^{a}4.24	8.328
Protein	CIP-Tanzania	3.28^{d}±0.04	4.56^{c}±0.13	6.35^{c}±0.03	5.69^{a}±0.01	0.191
	Ex-Igbariam	4.16^{b}±0.85	6.13^{a}±0.03	3.94^{d}±0.08	3.94^{c}±0.06	0.188
	TIS 87/0087	5.47^{a}±0.04	5.69^{b}±0.01	9.84^{a}±0.06	5.69^{a}±0.06	0.127
	TIS 8164	3.94^{c}±0.03	1.75^{d}±0.00	6.78^{b}±0.13	5.47^{a} ±0.04	0.190
Ash	CIP-Tanzania	1.40^{a}±0.14	1.60^{b}±0.14	1.60^{a}±0.00	1.40^{a}±0.00	0.2776
	Ex-Igbariam	1.70^{a}±0.14	2.00^{a}±0.14	1.80^{a}±0.42	1.60^{a}±0.42	0.878
	TIS 87/0087	1.30^{a}±0.42	1.20^{a} ±0.00	1.60^{a}±0.14	1.60^{a}±0.28	0.734
	TIS 8164	1.70^{a}±0.14	1.20^{a} ±0.00	1.40^{a}±0.28	1.70^{a}±0.14	0.481
Fiber	CIP-Tanzania	2.70^{ab}±0.14	2.40^{a}±0.14	2.20^{a}±0.14	2.00^{a}±0.28	0.519
	Ex-Igbariam	2.30^{b}±0.28	2.10^{a}±0.00	2.00^{a}±0.14	1.80^{a}±0.28	0.589
	TIS 87/0087	2.80^{b}±0.14	1.80^{a}±0.42	2.20^{a}±0.28	2.00^{a}±0.14	0.760
	TIS 8164	2.30^{b}±0.00	2.70^{a}±0.14	2.50^{a}±0.58	2.30^{a}±0.71	1.272
Fat	CIP-Tanzania	1.20^{a}±0.42	1.60^{a}±0.28	1.50^{a}±0.00	2.00^{a}±0.14	0.734
	Ex-Igbariam	1.40^{a}±0.14	1.40^{a}±0.00	1.60^{a}±0.28	1.80^{a}±0.42	0.734
	TIS 87/0087	1.10^{ab}±0.14	1.50^{a}±0.14	1.50^{a}±0.00	1.40^{a}±0.14	0.340
	TIS 8164	1.20^{a}±0.14	1.30^{a}±0.28	1.60^{a}±0.42	1.30^{a}±0.14	0.760
Carbohydrate	CIP-Tanzania	28.42^{a}±3.58	25.81^{ab}±1.82	22.35^{a}±2.94	23.91^{a}±1.00	7.049
	Ex-Igbariam	27.37^{a}±2.91	27.37^{ab}±1.53	25.66^{a}±3.38	21.86^{a}±4.02	7.863
	TIS 87/0087	19.33^{a}±7.45	22.81^{b}±2.28	18.86^{a}±2.63	20.31^{a}±3.90	12.636
	TIS 8164	29.86^{a}±3.93	28.05^{a}0.42	23.72^{a}±0.01	22.23^{a}±3.30	7.144

abc means ± standard deviation with similar superscript in the same row for each proximate component are not significantly different (p>0.05)

yield in cultivars of sweet potato. The implication of low ß-carotene yield for CIP Tanzania (Table 1) at 40-80kgN/ha may possibly be due to poor adaptation to Umudike ultisol and or low nitrogen response ability (Okon, 2006).

Ex-Igbariam and TIS87/0087 with higher ß-carotene yield agrees with the report of Okon (2006) which remarked that both Ex-Igbariam and TIS87/0087 are high nitrogen response varieties with interception of over 70% radiation resulting into a high photosynthetic activity (Uchida *et al*., 1982). Lintig (2007); Cavalcante and Rodriguez-Amaya (1992) and Kimura *et al*. (1991) observed the importance of light absorbing power of carotenoids at the visible spectrum (450-550 nm) to aid photosynthetic activities, thus, directly affecting carotenogenesis in fruits and vegetables. The difference in the ß-carotene concentrations observed in this work may be due to such positive influence of high radiation interception and photosynthetic activities of Ex-Igbariam and TIS87/0087 varieties of the sweet potato. The use of nitrogen fertilizer to produce sweet potato in Southeastern Nigeria agro ecological zone for ß-carotene yield may be best at 40-80 kgN/ha (Table 1).

Chemical composition: Table 2 indicates the effect of nitrogen fertilizer application on the proximate composition of sweet potato varieties. The results showed low dry matter with high amount of moisture (Table 2). The values obtained agrees with the data reported by Onuh *et al*. (2004) and Oboh *et al*. (1989). Nitrogen fertilizer application significantly ($p<0.05$) increased the protein content of the varieties at different nitrogen concentrations. For most varieties, protein yield was best at 40-80 kgN/ha with TIS87/0087 having the highest value of 9.84% at 80 kgN/ha (Table 2). This protein values are comparable to the average protein

Table 3: Effect of nitrogen concentration on the mineral content of each variety

Mineral	Variety	Nitrogen Concentration 0	40	80	120	LSD
P	CIP-Tanzania	20.00^{a}±2.83	18.80^{a}±0.28	22.60^{a}±0.85	22.50^{a}±0.42	4.1594
	Ex-Igbariam	27.50^{a}±0.71	19.10^{c}±1.27	22.60^{b}±0.14	18.80^{a}±1.70	3.1099
	TIS87/0087	20.10^{b}±0.14	19.10^{c}±0.28	15.00^{a}±0.71	25.00^{a}±2.83	4.0704
	TIS8164	25.00^{a}±0.00	21.00^{b}±1.41	20.30^{a}±1.70	12.50^{c}±0.71	3.2194
K	CIP-Tanzania	115.00^{c}±4.241	205.00^{a}±7.07	190.00^{ab}±14.24	150.00^{bc}±28.41	13.0206
	Ex-Igbariam	173.00^{b}±4.24	260.00^{a}±7.07	140.00^{c}±7.07	138.00^{c}±5.66	16.999
	TIS87/0087	203.00^{b}±2.83	218.00^{a}±2.83	203.00^{b}±7.07	198.00^{a}±2.83	11.276
	TIS8164	158.00^{c}±4.24	220.00^{a}±7.07	190.00^{a}±2.83	183.00^{a}±4.24	13.457
Na	CIP-Tanzania	28.00^{b}±4.24	45.00^{a}±7.07	35.00^{ab}±4.24	23.00^{b}±1.14	13.0206
	Ex-Igbariam	28.00^{a}±7.27	59.00^{a}±0.00	25.00^{ab}±2.83	28.00^{a}±5.66	10.5707
	TIS87/0087	33.29^{a}±2.83	28.00^{a}±1.41	40.00^{a}±11.31	35.00^{a}±2.83	16.7713
	TIS8164	23.00^{b}±4.24	60.00^{a}±2.83	53.00^{a}±5.66	28.00^{ab}±.4.24	12.1003
Ca	CIP-Tanzania	90.40^{a}±0.42	70.30^{b}±0.42	60.20^{c}±0.28	50.20^{d}±2.97	4.2237
	Ex-Igbariam	70.30^{a}±0.28	80.40^{a}±2.83	70.30^{a}±3.11	80.40^{a}±0.07	11.4255
	TIS87/0087	50.20^{b}±0.39	80.40^{a}±0.56	50.20^{b}±0.28	40.20^{c}±0.99	4.9852
	TIS8164	40.20^{d}±0.00	60.20^{c}±0.42	70.50^{b}±0.71	100.00^{a}±0.00	1.1446
Mg	CIP-Tanzania	30.40^{a}±0.28	24.30^{b}±0.42	18.20^{c}±0.42	30.40^{a}±2.40	3.4617
	Ex-Igbariam	12.20^{c}±0.28	24.39^{b}±0.99	18.20^{c}±0.57	30.40^{a}±1.27	1.6771
	TIS87/0087	12.20^{c}±0.71	18.20^{b}±0.28	18.20^{b}±1.27	30.40^{a}±1.27	2.7128
	TIS8164	18.20^{b}±0.00	12.20^{c}±1.13	24.30^{a}±0.99	24.30^{a}±0.99	2.0866

^{abc}means ± standard deviation with similar superscript in the same row for each mineral component are not significantly different (p<0.05)

value of 4.41 g/100 g reported by Ravindran *et al*. (1995) and 4.93-16.11% reported by Grant *et al*. (1992). The application of nitrogen fertilizer significantly decreased crude fiber in all the varieties. The higher fiber value observed for the control (Table 2) confirms the report of Igbokwe *et al*. (2005) that non-synthetic input cropping system enhanced crude fiber more than the conventional (chemical intensive) cropping system. The mean fat values for the different varieties ranged from 1.10-2.0%. Although these values were low, there are comparable to the values of 1.2-2.7% reported by Holloway *et al*. (1985). Also the low ash contents would mean that the sweet potato varieties might be low in some minerals. The carbohydrate content was high in most of the varieties. The high carbohydrate content of the sweet potatoes makes it a good source of energy.

Table 3 indicates the effect of nitrogen fertilizer application on the mineral content of the sweet potato varieties. Generally the application of nitrogen fertilizer significantly (p>0.05) decreased phosphorus content in most of varieties (Table 3). However, the value of potassium was significantly (p<0.05) increased for most of the varieties at different levels of nitrogen fertilizer application. Njoku *et al*. (2001) had reported that nitrogen and potassium were critical to sweet potato production. The blanket application of 150 kgN/ha as muriate of potash would have a positive influence on the potassium content at 40 kgN/ha for all the varieties. The effect of nitrogen fertilizer application also increased the sodium content significantly (p<0.05) for most of the varieties. Calcium and magnesium contents were significantly increased (p<0.05) for most of the varieties at the different levels of nitrogen fertilizer application.

Conclusion: The results obtained in this study shows that TIS87/0087 and Ex-Igbariam are the sweet potato varieties with the highest content of ß-carotene and protein. Nitrogen fertilizer application improved the ß-carotene and protein contents of most varieties at 40-80 kgN/ha while the control (no nitrogen fertilizer) was associated with the highest crude fiber values. The variability in the ß-carotene and chemical composition of the various varieties of sweet potato can be useful in directing sweet potato research production and consumption with the view to increasing nutritional (provitamin A and protein) status of the consumers.

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