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Assessment of Changes in Beta-carotene Content and Sensory Attributes of Two Sweet Potato Varieties as Influenced by Organic and Inorganic Fertilizers and Storage Methods

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Authors' contributions

This work was carried out in collaboration between all authors. Authors HKD, JOA and ETB designed the study and wrote the protocol. Author MEE wrote the first draft of the manuscript, managed the literature searches, analyses of the study and performed the spectroscopy analysis. Authors JOA, ETB and JCN managed the experimental process and identified the species of plant. All authors read and approved the final manuscript.

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ABSTRACT

Two field experiments were conducted at two seasons at the research fields of the University of Education, Winneba-Mampong campus from September, 2011 to January, 2012 and April to July, 2012 to assess changes in beta-carotene content and sensory attributes of two sweet potato varieties (*Okumkom* and *Apomuden*) grown under organic and inorganic fertilizers and three different storage methods in Ghana. Cooked samples of the harvested sweet potato roots were evaluated for their sensory attributes. In the storability studies, the harvested roots were sorted, cured and stored under three storage methods for 3 months. The beta- carotene changes in the

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stored roots were assessed. There was a significant difference ($p<0.05$) between *Apomuden* and *Okumkom* grown under amendment and the control in beta-carotene content at harvest and in pit store in both seasons. The beta- carotene content of *Apomuden* increased by 15-30% in pit store during the minor season than at harvest. Both varieties grown under amendment and the control and stored in pit was the most effective storage method in terms of beta-carotene over ash and grass storage in both seasons. There was a significant difference ($p<0.05$) between *Okumkom* and *Apomuden* in root texture and palatability at harvest and after cooking during the minor season. *Apomuden* differed significantly ($p<0.05$) from *Okumkom* in root colour and flavour at harvest and after cooking during the major season. The application of 30-45-45 kg/ha NPK to both varieties was more acceptable with regard to root taste, colour and palatability than the other treatments during the minor season.

Keywords: Sweet potato; beta-carotene; Apomuden cultivar; Okumkom cultivar; sensory attributes.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* [L.] Lam) belongs to the family Convolvulaceae and order Polemoniales [1]. It is grown around the world in diverse environments often by small holder farmers in marginal soils using low inputs [2]. It is the third most important root crop after potato and cassava in the world and one of the root and tuber crops largely grown in East Africa as staple for rural communities [3]. In 2005 yellow–to orange-fleshed sweet potato (OFSP) varieties with increased levels of beta-carotene content were released in Ghana. Although the majority of sweet potato varieties are high in carbohydrates, orange-fleshed sweet potato (OFSP) varieties also provide vitamins A and C [3]. Both the roots and leaves may contain substantial amounts of vitamins, particularly vitamin A. Vitamin A plays crucial roles in vision, cellular differentiation and morphogenesis, haemopoiesis, skeletal growth and fertility in humans [4]. Despite this remarkable potential of the crop, Vitamin A Deficiency (VAD) is widespread and the most common cause for young children blindness in the developing world [5]. Most sweet potato varieties currently grown by farmers are poorly adapted, have low root yields, less nutritive and white fleshed which have no beta-carotene, a precursor of vitamin A [6]. But among the cheapest and richest source of vitamin A, OFSP varieties rich in beta-carotene are well accepted by consumers [5]. The intensity of orange coloured flesh in sweet potatoes root indicates the level of beta-carotene [7]. Retention of carotenoids after boiling is more important since majority of common people consume sweet potato roots after boiling. The people who were traditionally dependent on the consumption of white-fleshed local cultivars were unaware of the nutritive value of orange- fleshed sweet potato as most of the varieties selected by the consumers were based on the best taste, flavour and texture rather than those having a better nutrient profile [8]. Sensory attributes such as appearance, taste, texture, stickiness and softness could contribute immensely to the acceptability or otherwise of any food crop. Kader [9] reported that factors such as appearance (visual), flavour (taste and smell), texture, nutritive value and safety are very important criteria for assessing the quality of processed sweet potato roots.

Stored sweet potato roots undergo many physiological changes that affect their beta-carotene content and bio-availability as well as the tissue microstructure. Storage of OFSP roots using methods that maintain low temperatures leads to higher retention of beta-carotene [10]. However, after four months of storage of sweet potato roots, up to 70-80% of the vitamin A in the sweet potato can be lost [11]. Expanding sweet potato for industrial uses must be backed up by innovative postharvest technologies. It is therefore important to optimize nutrient supply for high yield in the commonly cultivated sweet potato types in Ghana and to carry out a systematic study of the effects of some storage methods on the stored sweet potatoes. The study was to evaluate the sensory attributes and changes in sweet potato root quality (beta-carotene content) of two sweet potato varieties grown under different organic and inorganic fertilizer levels and stored under different storage methods.

2. MATERIALS AND METHODS

2.1 Sample Source

The root samples used for the evaluation of the sensory attributes and storage study were obtained from four months old two sweet potato varieties (*Okumkom* - a white-fleshed variety)

and (*Apomuden* - a deep orange-fleshed variety) grown under eight fertilizer treatments [(i) 10 t/ha chicken manure (CM), (ii) 30-30-30 kg/ha NPK, (iii) 15-15-15 kg/ha NPK + 5 t/ha CM, (iv) 30-45-45 kg/ha NPK, (v) 15-23-23 kg/ha NPK + 5 t/ha CM, (vi) 30-60-60 kg/ha NPK, (vii) 15-30-30 kg/ha NPK + 5 t/ha CM and (viii) No fertilizer (control)] in a field experiment conducted at the research fields of the College of Agriculture Education, University of Education, Winneba, Mampong-Ashanti campus from September, 2011 to January, 2012 (minor season) and April to July, 2012 (major season).

The weather conditions during the experimental periods show that differences in climatic factors (rainfall, temperature and relative humidity) were observed between both cropping seasons. The total monthly rainfall in the minor season was 429.8 mm and it occurred from September, 2011 to January, 2012 with the peak in September and October. The mean monthly temperature of the area for the minor season ranged between 23℃ to 31.9℃ with the highest daily of 33.7℃ occurring in January, 2012 [12]. The mean monthly relative humidity ranged from 54 to 93.4% with the peak occurring between September and November. The bimodal rainfall pattern of Mampong-Ashanti gave the area two seasons; the major season occurred between March and July and the minor from September to November with one month drought spell in August [12]. In the major rainy season (2012), the total monthly rainfall was 1,042.3 mm and it occurred from April to August, 2012 with the peak in May and July. The mean monthly temperature of the site for the major season ranged between 22.5℃ to 30.1℃, with the highest daily of 33.3℃ occurring in April. The mean monthly relative humidity ranged from 67.4 to 93.4% with the peak occurring between April and June [13].

2.2 Evaluation of Sensory Attributes

The evaluation of sensory attributes was conducted the day the roots were harvested according to the procedure described by Ofori et al. [14]. The fresh harvested sweet potato roots were washed and three representative samples of each treatment were placed in a labeled polythene and cooked separately in pre-heated (boiling) water for 30 minutes. They were boiled with 8.0 g of iodated salt dissolved in 1000 ml of water. The cooked roots were cut into cubes of size 2 cm x 2 cm x 2 cm, coded randomly and served to panelists for evaluation. A six (6) member panel of regular sweet potato consumers consisting of three males and three females, aged between 25 and 43 years old who had been selected and trained were used in the sensory evaluation. The cooked samples were served to the panelist's who evaluated them for their colour (surface and inner flesh), flavour, taste, texture, palatability and overall acceptability on a scale of 1 to 5, with 1 representing 'very poor' and 5 representing 'very good'. The panelist's score for each treatment was averaged. Colour examination was carried out through the panelist's visual assessment of the boiled sweet potato varieties as they were served. Texture was assessed by determining the fibrous nature of the roots while chewing. Palatability assessment was carried out by the combination of taste and colour while chewing and swallowing the tuber.

2.3 Storage Studies

Eight clean roots (without bruises or signs of insect pest attack) were randomly selected from each treatment for each of the storage methods from the field experiment after harvest and stored for 12 weeks under three storage methods (pit, ash and grass). The experimental design used was randomized complete block design where the two varieties and fertilization constituted the treatments and were each replicated three times. A simple random sampling technique was used to select roots from each treatment and replicate. The random sampling approach was to ensure that the parameters under observation are taken from representative universe of units from each replicate and treatment. In each pit or basket used for the ash and grass storage methods, there were a total of 112 roots that were monitored for 12 weeks. The beta-carotene content of the freshly harvested sweet potato and the 12 week old stored roots were analysed.

2.4 Pit Storage Method

The pit storage method (Mutandwa and Tafara, [15]; Tumuhimbise et al. [16]), consisted of a circular pit of size 0.5 m diameter x 0.5 m wide x 0.5 m depth. The size of the pit was chosen to suit local climatic conditions and is a modification of the traditional pits. The pit was lined with dry plantain leaves before the sweet potato roots were stored in them. Layers of roots as per treatment were separated with about 1.0 kg dry spear grass (*Imperata cylindrica*). The sweet potatoes roots were finally covered with dry spear grass before covering them with

approximately 2.0 kg of soil. The grass acted as an insulating material and ensured cool condition in the pit (17℃, RH 95-100%). The pit was constructed under a shade to prevent rain water from entering the storage pit.

2.5 Ash Storage Method

The ash storage method consisted of wood ash packed in a basket of size 50 cm x 50 cm x 70 cm lined with a layer of dry plantain leaves. The roots as per treatment were thoroughly coated with wood ash by mixing them with two (2) kg of wood ash (Mutandwa and Tafara, [15]). The roots were then alternated with 1.0 kg of dry spear grass. The ash acted as an absorbent to moisture and has a repelling effect on pests. Wood ash has alkaline properties, which are not conducive for the development of diseases.

2.6 Grass Storage Method

The grass storage method consisted of grass packed in a basket of size 50 cm x 50 cm x70 cm lined with dry plantain leaves with roots alternating with layers of grass and finally covered with a grass (Mutandwa and Tafara, [15]). Layers of roots as per treatment were separated with about 1.0 kg dry spear grass (*Imperata cylindrica*). The sweet potatoes were then finally covered with dry spear grass at the top. The beta-carotene content of the freshly harvested sweet potato and the 12 week old stored roots were analyzed.

2.7 Beta-carotene Determination

The carotenoids analyses were carried out at the Nutrition Department of the Noguchi Memorial Institute for Medical Research (NMIMR), University of Ghana, Legon, using a rapid reversed- phase high performance liquid chromatography (HPLC) methodology according to the procedure by Rodriguez-Amaya [17].

2.8 Sample Preparation

All samples were refrigerated prior to the carotenoids analyses. The analyses were performed in a dark room due to the light sensitive nature of carotenoid. Three freshly harvested sweet potato roots randomly selected from each treatment were washed with clean water, packaged in aluminum foil, labeled and stored at -4℃. The samples were shredded later with a plastic grater and made to pass through a 0.2 mm mesh, packaged in well labeled test tubes and stored at - 4℃ for subsequent β-carotene analysis using HPLC. Precautionary measures such as exclusion of oxygen, and protection from light were taken to prevent carotenoid losses. Similar sweet potato sample preparations were carried out after the three month storage of roots from each of the storage method for β- carotene analysis using HPLC.

2.9 Carotenoids Extraction

Prepared sweet potato root sample (1.0 g) from each treatment was weighed using an electronic balance (Sartorius, Analytic $AC210_s$) into previously weighed porcelain mortars. The sample was ground with pestle in 20 ml HPLC grade cold acetone (Sigma Aldrich, USA) for five (5) minutes until fine slurry was obtained. The residue was filtered in Butcher funnel equipped with filter paper (Whatman # 2 filter paper, Maidstone, England). The residue was returned to the mortar and the extraction was repeated using 20 ml of cold acetone (Sigma Aldrich, USA) until the residue was nearly colourless. Precautionary measures such as exclusion of oxygen, and avoiding temperatures above 40℃ were taken to prevent carotenoid losses during extraction and analysis. Internal standard (β-apo-8´-carotenal) was added at the beginning of the analysis to appraise losses of carotenoids during extraction and the entire work-up procedures.

2.10 Partition

Since the acetone used during the extraction is water-soluble, and also has damaging effect on HPLC system, it was washed away as described by Rodriguez-Amaya [17]. The total extract was gently and carefully transferred to a separating funnel (250 ml) containing 20 ml of petroleum spirit. Two distinct phases (lower and upper) were formed during the washing. The water used for washing was allowed to flow along the wall of the separating funnel. The lower acetone-aqueous phase was carefully discarded without losing the upper phase (extract). Washing procedure continued for five more times with 200 ml of distilled water at each time until the lower phase appeared extremely clear, indicating complete removal of acetone from the extract. The upper phase (petroleum-extract) was collected over about 5.0 g anhydrous sodium sulphate (dry agent) to absorb residual water in the extract. The final volume of the extract in the tube was recorded.

2.11 Carotenoids Identification

The petroleum spirit used during the partition was evaporated from the extract because of its damaging effect on the HPLC equipment. 2 mls of the total volume of the extract was evaporated on rotary evaporator with nitrogen gas to dryness. The evaporated extracts were used for the spectrophotometric analysis and injection in the HPLC.

A rapid reversed-phase HPLC was used for the analysis of the carotenoids. The HPLC system was calibrated using the Internal standard of pure carotenoids and was washed thoroughly using the mobile phase (a mixture of acetonitrile/dichloromethane/methanol) in the ratio (7:2:1 v/v/v) for ten (10) minutes immediately before injection. The dried extracts in the test tubes were dissolved in a mixture of methanol/dichloromethane (50%:50% v/v) and vortexed. About 20 µl of the re-dissolved extract was injected into the HPLC using a syringe. The extract was pumped at a rate of 1.5 ml/minute from the injector into the stationary column, where separation of the carotenoids took place according to their polarity. The absorbance of the carotenoids was determined at a wavelength of 450 nm. The standard carotenoids and the extracts were injected separately in equal volumes into the HPLC. The identification of the carotenoids from the extract was based on the isocratic elution (retention) time between the standard carotenoids and extracts.

2.12 Carotenoids Quantification

The concentrations of the carotenoids in the extracts were calculated by comparing the concentration and area under the peak of the standard carotenoids with the area under the peak of the carotenoid in the extract. The total carotenoid content was calculated according to Davies [16] using the absorption coefficient $A_{1CM}^{1\%}$ of beta-carotene in petroleum ether (i.e., 2592)

The concentration of each identified carotenoid was calculated according to the following formulas:

$$x\ (\mu g) = A \bullet y\ (mL) \bullet 10^6 / A_{1CM}^{1\%} \bullet 100$$

$$x\ (\mu g/g) = x\ (\mu g) / \text{weight of sample (g)}$$

(Rodriguez-Amaya[17]):

where x is the weight or concentration of the carotenoid, y is the volume of the solution that gives an absorbance of A at a specified wavelength $A_{1CM}^{1\%}$, is the absorption coefficient of the carotenoid in the solvent used. For example, for β- carotene in petroleum ether, the absorbance (A) at 450 nm and an $A_{1CM}^{1\%}$ of 2592 was used.

2.13 Statistical Analysis

The data collected were analysed using Analysis of Variance (ANOVA) using the GenStat statistical package [18] and the Least Significant Difference (LSD) was used to separate the means at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Beta-carotene Analysis of Roots at Harvest

There was a significant difference ($p<0.05$) between *Apomuden* and *Okumkom* in beta-carotene content at harvest during the minor and the major seasons (Table 1). The significant difference between *Apomuden* and *Okumkom* in beta-carotene content in both growing seasons might be due to differences in variety and its response to soil fertility as well as differences in climatic conditions. According to Bengtsson et al. [19] beta-carotene concentrations vary with growing conditions and season [20]. This result in similar to those found by Bengtsson et al*.* [19] and Wu et al*.* [21] that beta-carotene concentrations depend largely on the variety and the growing conditions and season. Rodriguez-Amaya and Kimura [22] reported that in a given food, qualitative as well as quantitative differences exist due to factors such as variety. *Apomuden* grown during the major season produced higher beta-carotene content than during the minor season. This might be due to differences in climatic conditions. Sweet potato tuber formation undergoes many physiological changes due to production condition that affect their beta-carotene content. The high temperature coupled with long drought experienced during the minor season might have increased the rate of metabolism in tubers. High temperatures can be detrimental to the tuber quality by reducing the beta-carotene content. The low temperature experienced during the major season might have resulted in high retention of beta-carotene content of tubers [12]. This agrees with Degras [23] that the range of vitamin A found in sweet potato is quite wide and that the range of values within a specific vitamin depends primarily on cultivar, but there is strong interaction with environmental factors. There was

a significant difference ($p<0.05$) between amended plots and the control in beta-carotene content at harvest in both growing seasons (Table 1). The significant difference between amended plots and the control might be due to differences in soil fertility. The application of 15-30-30 kg/ha NPK +5t/ha CM differed significantly ($p<0.05$) in beta-carotene content from the other amended plots and the control at harvest during the minor season. This might be due to the slow release of nitrogen and phosphorus from chicken manure and inorganic fertilizer. This result is similar to Degras [23] that N and P increase the beta-carotene content of the sweet potato roots during bulking and also affects the unit weight of tuberous roots, especially under good environmental conditions. The application of 30-45-45 kg/ha NPK differed significantly ($p<0.05$) in beta-carotene content from the other amended plots and the control during the major season (Table 1). The significant difference might be due to the initial release of nitrogen from inorganic fertilizer and good climatic condition in terms of high rainfall and low temperature during the major season. Villagaria [24] reported that nitrogen fertilizer application for optimum beta-carotene yield depend on variety and environmental variations. The application of organic manure either singly or in combination with inorganic fertilizer gave higher beta-carotene content during the minor season than in the major season. This might be due to differences in soil fertility and climatic conditions.

3.2 Beta-carotene Analysis at 12 Weeks in Storage

There was a significant difference ($p<0.05$) between *Apomuden* and *Okumkom* stored in pit in beta-carotene content in both growing seasons (Table 1). The significant difference between *Apomuden* and *Okumkom* in beta-carotene content in pit store might be due to differences in variety and storage condition. The positive response of *Apomuden* to pit storage with regards to increase in beta-carotene content in the current study had similarly been reported by Tumuhimbise [16] that orange-fleshed sweet potato roots stored in pits maintained high beta-carotene content. *Apomuden* stored in pit during the minor season produced higher beta-carotene content than during the major season. This might be due to differences in climatic conditions during storage of roots. *Apomuden* and *Okumkom* stored in pit produced higher beta-carotene content than roots stored in ash during the major season. This might be due to differences in storage conditions. Sweet potato roots undergo many physiological changes due to storage conditions that affect their beta-carotene content. This is similar to Tumuhimbise [16] that storage of sweet potato roots using methods that maintain low temperatures leads to high retention of beta- carotene. There was a significant difference ($p<0.05$) between amended plots and the control in beta-carotene content in pit store in both growing seasons (Table 1). The significant difference between amended plots and the control might be due to differences in soil fertility. The application of 10t/ha CM differed significantly in beta-carotene content in pit store from the other amended plots and the control during the minor season. There was a significant difference ($p<0.05$) between amended plots and the control in beta-carotene content in pit store in both growing seasons. The application of 15-23-23 kg/ha NPK +5t/ha CM differed significantly ($p<0.05$) in beta-carotene content in pit store from the other amended plots except 30-60-60 kg/ha NPK and the control during the major season (Table 1). This might be due to differences in soil fertility and climatic conditions. The application of amendment except 30-60-60 kg/ha NPK and the control gave higher beta-carotene content in pit store during the minor season than in the major season. This might be due to differences in soil fertility and climatic conditions during storage. The application of amendment and the control to sweet potato roots stored in pit produced higher beta-carotene content than roots stored in ash during the major season. This result might be due to high temperature in ash storage condition. Pit storage was protected from direct sunlight and therefore the transfer of moisture was biased towards gain rather than loss while storage in ash resulted in moisture losses which were also accompanied with the nutrient losses. This is similar to Tumuhimbise [16] that sweet potato roots stored in the pit maintained significantly more moisture content than any other storage method. *Apomuden* and *Okumkom* stored in pit produced higher beta-carotene content than at harvest (Table 1). This might be due to the storage condition. This result however contradicts Bechoff [25] that sweet potato roots stored after four months loses up to 70-80% of the vitamin A.

3.3 Sensory Characteristics of Boiled Sweet Potato Roots

There was a significant difference ($p<0.05$) between *Okumkom* and *Apomuden* in root texture at harvest and after cooking in both

seasons (Table 2). The significant difference between the two varieties in texture might be due to differences in variety characteristics in terms of fibrous texture of *Okumkom.* Texture assessment was aimed at determining the fibrous nature of the sweet potato roots while chewing. This is similar to Degras [23] that dry textured tubers are generally preferred in the tropics and in other traditional growing areas. Ofori et al. [14] reported that the adoption of such varieties such as *Okumkom* with high fibrous root texture in local food preparations such as '*ampesi'* will 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.

Table 1. Beta-carotene content of sweet potato root at harvest and stored in pit and ash for 12 weeks during the minor season and the major season

Treatments	Beta-carotene content of roots at harvest (mg/100 g)		Beta-carotene content of roots at 12 weeks in storage (mg/100g)		
			Pit		Ash
	Minor season	Major season	Minor season	Major season	Major Season
Variety					
Apomuden	9.9	14.1	28.3	14.1	0.1
Okumkom	4.1	1.8	5.2	1.8	1.2
LSD (0.05) variety	0.62	0.03	0.49	0.02	0.003
Fertilizer rates					
10t/ha CM	8.4	2.3	27.0	9.7	1.1
30-30-30 kg/ha NPK	2.9	6.7	18.0	6.1	1.0
15-15-15 kg/ha NPK + 5t/ha CM	7.7	6.9	16.2	8.5	1.1
30-45-45 kg/ha NPK	2.7	7.8	15.7	8.6	0.8
15-23-23 kg/ha NPK + 5 t/ha CM	6.1	1.6	17.2	11.9	0.8
30-60-60 kg/ha NPK	3.3	3.8	2.7	8.8	0.7
15-30-30 kg/ha NPK + 5 t/ha CM	19.5	0.7	16.3	7.1	0.0
No fertilizer (Control)	5.1	1.7	12.7	3.0	0.0
LSD (0.05) fertilizer	1.24	0.05	0.98	0.04	0.01
LSD (0.05) variety x Fertilizer	1.75	0.07	1.39	0.00	0.01

Table 2. Sensory characteristics of boiled *Apomuden* and *Okumkom* roots at harvest during the minor season and the major season

Treatments	Taste		Texture		Colour	
	Minor season	Major season	Minor Season	Major season	Minor season	Major season
Variety						
Apomuden	3.3	3.4	2.0	2.2	3.8	4.1
Okumkom	3.7	3.4	3.0	2.7	3.3	3.3
LSD (0.05) variety	0.4	NS	0.27	0.27	0.39	0.39
Fertilizer rates						
10t/ha CM	3.4	2.7	2.2	3.0	3.3	3.8
30-30-30 kg/ha NPK	3.7	3.1	2.6	2.6	3.3	3.5
15-15-15 kg/ha NPK + 5t/ha CM	3.5	4.2	2.7	2.7	3.3	3.3
30-45-45 kg/ha NPK	4.2	3.3	2.6	2.6	4.2	4.4
15-23-23 kg/ha NPK+5 t/ha CM	3.2	4.3	2.5	1.6	3.9	4.0
30-60-60 kg/ha NPK	3.6	3.5	2.7	2.3	3.5	3.2
15-30-30 kg/ha NP + 5 t/ha CM	3.1	3.6	2.8	2.1	3.0	3.4
No fertilizer (Control)	3.6	3.6	2.3	2.6	3.6	3.7
LSD (0.05) fertilizer	NS	NS	NS	NS	NS	NS
LSD (0.05) variety x Fertilizer	1.13	1.08	0.77	0.77	1.12	0.12

There was a significant difference ($p<0.05$) between *Apomuden* and *Okumkom* in root colour at harvest and after cooking in both seasons (Table 2). The significant difference might be due to differences in variety in terms of root colour. This had similarly been reported by Bengtsson [19] and Wu [21] that sweet potato varies in colour which depends largely on variety. *Apomuden* with its highly preferred colour could be attributed to its orange -fleshed colour conferred on it by the high beta-carotene content. Carotenoid concentrations varied with sweet potato colour and that the more orange the colour the higher the carotenoid content [26]. Ofori et al. [14] reported that orange-flesh sweet potato varieties have been identified as a rich source of carotenoids and that the incorporation of sweet potato into local food preparations will increase its potential as a cash crop in Ghana. There was no significant difference ($p<0.05$) between amended and the control in root texture, taste and colour at harvest and after cooking in both seasons (Table 2). The non- significant difference might be due to the fact that application of amendment had no influence on root texture, colour or taste but rather variety. There was a significant difference ($p<0.05$) between *Apomuden* and *Okumkom* in root flavour and overall acceptability at harvest and after cooking during the major season. *Okumkom* differed significantly ($p<0.05$) from *Apomuden* in root palatability and overall acceptability during the minor season (Table 3). This might be due to differences in variety and climatic conditions. This agrees with Kader [9] who reported that factors such as appearance (visual), flavour and texture are very important criteria for assessing the quality of processed sweet potato roots.

There was no significant difference ($p<0.05$) between amended and the control in root flavour at harvest and after cooking in both seasons (Table 3). The non- significant difference might be due to the fact that application of amendment had no influence on root flavour. There was a significant difference ($p<0.05$) between 30-45-45 kg/ha NPK and 15-23-23 kg/ha NPK + 5t/ha CM in palatability of roots during the minor season. This might be due to differences in soil fertility. 30-45-45 kg/ha NPK treated roots differed significantly from the other amended and the control root in overall acceptability during the minor season (Table 3). The significant difference between 30-45-45 kg/ha NPK and other amended and the control roots in overall acceptability during the minor season might be due to the fact that most of its cooking qualities (taste, texture, colour and palatability) were preferred. This is similar to Adu-Kwarteng et al*.* [27] that among the five sweet potato varieties studied in Ghana, 91/198 consistently emerged as the best variety, due to the fact that most of its qualities were preferred after cooking. Ofori et al. [14] reported that taste relates to the panelist's assessment of the sweetness level of the boiled varieties and that the sweetness level of sweet potato can influence the area of its utilization. Adu-Kwarteng et al. [27] reported that

Table 3. Sensory characteristics of boiled *Apomuden* and *Okumkom* roots at harvest during the minor season and the major season

Treatments	Flavour		Palatability		Overall acceptability	
	Minor season	Major season	Minor season	Major season	Minor season	Major season
Variety						
Apomuden	3.4	3.6	3.0	3.6	15.6	17.0
Okumkom	3.4	3.3	3.8	3.6	17.2	16.0
LSD (0.05) variety	NS	0.40	0.36	0.27	0.30	0.39
Fertilizer rates						
10t/ha CM	3.2	3.6	3.4	3.4	10.5	8.3
30-30-30 kg/ha NPK	3.3	2.9	3.5	3.2	16.3	15.5
15-15-15 kg/ha NPK + 5t/ha CM	3.3	3.7	3.8	4.3	16.5	18.3
30-45-45 kg/ha NPK	3.5	3.6	3.9	3.3	18.3	16.6
15-23-23 kg/ha NPK + 5 t/ha CM	4.1	3.7	2.6	4.4	16.5	18.0
30-60-60 kg/ha NPK	3.7	3.6	3.3	3.5	16.7	16.2
15-30-30 kg/ha NPK + 5 t/ha CM	3.0	3.3	3.0	3.6	14.9	14.3
No fertilizer (Control)	3.3	3.2	3.4	3.9	16.3	17.0
LSD (0.05) fertilizer	NS	NS	0.73	NS	0.60	NS
LSD (0.05) variety x Fertilizer	1.08	1.13	NS	0.77	NS	0.12

for products such as snack foods and desserts, the sweet taste is highly preferred. There was no significant difference ($p<0.05$) between amended and the control roots in palatability and overall acceptability during the major season.

4. CONCLUSION

For high beta-carotene content of sweet potato, farmers should grow *Apomuden* in both seasons than *Okumkom.* Farmers should store sweet potato roots in pit than in ash or grass after harvest for high beta-carotene content in both growing seasons. Farmers are to grow sweet potato on amended plots, especially on15-30-30 kg/ha NPK +5t/ha CM and 10t/ha CM plots during the minor season and on 30-45-45 kg/ha NPK plot during the major season for high beta-carotene content. Farmers should grow sweet potato, especially *Okumkom* on 30-45-45 kg/ha NPK plot for fibrous texture, palatable and overall acceptable roots during the minor season. Farmers should grow *Apomuden* during the major season for high root colour, flavour and overall acceptable roots. This suggests the need to modify the nutrient supply according to environmental conditions. Knowledge of these changes can facilitate the estimation of growth period, modification of nutrient supply in relation to environmental conditions, storage condition and time for different sweet potato varieties in order to meet different food industry needs.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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