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Research Article

Effect of Spacing and Maturity on Phenolic Phytochemical Composition of Umuspo1 and Ex-Onyunga Varieties of Orange Fleshed Sweet Potato at 12 and 16 Weeks

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Abstract

This study examined phenolic phytochemical composition of two (2) Orange Fleshed Sweet Potatoes (OFSP) (*Ipomoea batatas*) varieties. The OFSP (Ex-Onyunga and Umuspo1) varieties were planted at different spacing 20 cm, 30 cm and 40 cm, respectively and harvested at 12 and 16 weeks. Flavonoid, Total polyphenol, Beta-carotene peels and Beta-carotene flesh contents were evaluated for Phenolic Phytochemical contents. Data generated were subjected to analysis of variance (ANOVA) using SPSS version 17. The flavonoid content of the Ex-Onyunga OFSP varieties planted at 20 cm, 30 cm and 40 cm at 12 weeks recorded the concentrations of 283.54 µg/g, 288.33 µg/g and 291.88 µg/g, respectively, and the Umuspo1 OFSP varieties planted at 20 cm, 30 cm and 40 cm at 12 weeks also recorded the concentrations of 263.13 µg/g, 268.33 µg/g and 275.21 µg/g, respectively. The flavonoid content of Umuspo1 OFSP varieties with the distance spacing of 20 cm, 30 cm and 40 cm had concentrations 268.54 µg/g, 270.00 µg/g and 276.25 µg/g, respectively, while Ex-Onyunga of OFSP varieties with the distance spacing of 20 cm, 30 cm and 40 cm had the concentrations of 260.63 µg/g, 226.25 µg/g and 248.54 µg/g, respectively. The total polyphenol content of Umuspo1 OFSP variety with the distance spacing of 40 cm had the highest value [41.99 µg/g], and significantly *[$P<0.05$]* different from the total polyphenol content of all other samples. There were significant (*$P<0.05$*) differences in the Beta-Carotene contents of flesh and peels. The Beta- carotene of flesh sample recorded values ranged from 184.31 µg/g + 0.93 µg/g to 335.47 µg/g + 1.69 µg/g at 12 weeks, and also recorded another values ranged from 189.11 µg/g + 2.17 µg/g to 216.97 µg/g + 0.28 µg/g at 16 weeks, while the Beta-carotene peels sample recorded values ranged from 323.67 µg/g + 9.17 µg/g to 386.39 µg/g + 3.85 µg/g at 12 weeks, and also recorded another values ranged from 336.11 µg/g + 7.90 µg/g to 347.16 µg/g + 2.00 µg/g at 16 weeks, respectively. The calculated retinol equivalent of two OFSP varieties [Umuspo1 and Ex-Onyunga] at different spacing distances enhanced results as *trans-β*-carotene of Umuspo1 and Ex-Onyunga OFSP recorded values ranged from 11.79 *µ*g/g to 146.20 *µ*g/g. Among the samples analyzed, the Umuspo1 (US_2) variety of OFSP planted at 30 cm exhibited the lowest concentrations of both carotenoids. Specifically, its 13-cis carotene content was 0.72 µg/g, while the 9-cis carotene content was 0.34 µg/g, both values being lower than those recorded for all other varieties and planting distances.

Keywords

Composition, Effect, Maturity, OFSP, Spacing

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1. Introduction

The major phytochemicals that are generally present in sweet potato are flavonoids, terpenoids, tannins, saponins, glycosides, alkaloids, steroids and phenolic acids. These constituents may vary with varieties depending on flesh and skin colours. Orange Fleshed Sweet Potatoes (OFSP) varieties are particularly rich in beta-carotene, while purple sweet potato contains higher anthocyanin content than other varieties of sweet potato [1]. Phytochemicals such as flavonoids and related phenolic compounds which are generally present in sweet potatoes have been reported to have multiple biological effects, such as anti-oxidant activity. Purple-fleshed variety has been reported to contain anthocyanin, which possesses activity [2]. Antioxidants act as scavengers of free radicals reactive oxygen species inside the cell [3]. Many evidence suggest that degenerative diseases such as cancer, asthma, diabetes, senile dementia and eye disease have their origin in deleterious free radical reactions [4]. The free radical scavenging activity of extracts from the leaves of 8-cultivars of sweet potato was confirmed using 1, 1-dipenyl-2-picrylhydrazyl [DPPH] assay. In the root tubers of sweet potato, antioxidant activity has also been demonstrated in different cultivars [5, 6]. A stronger antioxidant activity reported in the peels of white and purple varieties when compared to the flesh samples [7], showing that the skin of sweet potato root tuber is also a rich source of anti-oxidative phytochemicals. Orange fleshed sweet potato [OFSP] contains beta-carotene, which comes in natural forms. It consists of roughly equal amounts of *9-cis* and *all-trans* isomer with small amounts of the *13-cis* isomer though synthetic beta carotene is primarily composed of the all-trans isomer with small residues of the *13-cis* isomer [8]. Although all-trans-beta carotene is converted into vitamin A, which plays an essential role in vision, growth, reproduction, immune function and maintenance of the skin and mucous membranes, the *9-cis* isomer is not converted into vitamin A, but does act as a powerful antioxidant [9]. The consumption of food based antioxidants like beta-carotene seems to be useful for the prevention of macular degeneration and cataracts [10]. According to [11], Beta-carotene has potential antioxidant and biological properties due to its chemical structure and interaction with biological membranes. It is well-known that Beta-carotene quenches singlet oxygen with a multiple higher efficiency than 〈-tocopherol [12].

2. Materials and Methods

The raw materials for this study were two varieties of Orange Fleshed Sweet Potato [Umuspo1 and Ex-Onyunga] planted at different soil nutrients management treatments at student's Research Farm of National Root Crops Research Institute, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The root tubers were harvested at 12 and 16 weeks maturity. Each variety was replicated and assigned as ES_1 ES_2 ES_3 for Ex-Onyunga and US_1 US_2 US_3 for Umuspo1 planted at different spacing 20 cm, 30 cm and 40 cm, respectively, and data generated were subjected to analysis of variance [ANOVA] using SPSS version 17.

3. Field Work

The field work was carried out by the Agronomy students of Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Sweet potato vine cutting of 20cm length with at least 4 nodes were planted along the crest of the ridges. Supply of vacant stands was done 2 weeks after planting.

4. Treatment

The treatments were arranged as a split plot in Randomized Complete Block Design [RCBD] with three [3] replications. The main plot treatments were two varieties [Ex-Onyunga and Umuspo 1] of Orange Fleshed Sweet Potato [OFSP]. The sub-plot treatments were eight nutrient combinations with control. 1 = Control, 2 = poultry manure at 10 t/ha: 3 = poultry manure at 5 t/ha: 4= NPK 15:15:15 at 400kg/ha: 5 = Agrolyser at 5.3 t/ha: 6 = poultry manure at 2.5 t/ha + NPK 15:15:15 at 200kg/ha: 8 = Agrolyser + NPK at 200kg/ha VA: 9 = poultry manure at 2.5t/ha NPK at 200kg/ha + Agrolyser at 2.7kg/ha [Agrolyser: Ca -20.4%, Na – 1.04%, Zn – 0.11%, S – 2.72%, Fe, Mn,].

Chemical analysis showed that the poultry manure had pH = 7.06, N= 2.1%, P=1.06% and K=0.62%. The poultry manure were applied into appropriate plots after ridging, while NPK was applied 4 weeks after planting by brand placement. Each sub-plot measured 3 m x 2 m [6m^2].

5. Experimental Design

The soil for the experiment was sand-loamy, 78.8% and 6.8% slit, 14.4% clay, 4.7pH, 1.59% organic matter, 0.08% nitrogen [N], 32.10mg/kg Phosphorous [P] and 0.35mg/kg Potassium [K].

6. Results and Discussion

Table 1. *Phenolic Phytochemical Composition of the Peels and Flesh of Orange-Fleshed Sweet Potatoes [Ex-Onyunga and Umuspo1] Varieties at 12 and 16 Weeks.*

Potato *spp* Samples							
		US_1	**US_2**	**US_3 Spacing [cm]**	**ES_1**	**ES_2**	**ES_3**
Parameters [µg/g]	MP WK	20	30	40	20	30	40
Flavonoid	12	268.33+5.64^{cd}	263.13 +18.82^{d}	275.21+4.16^{bcd}	288.33+5.64^{ab}	283.54+1.57^{abc}	291.88+2.73^{a}
	16	268.54+12.14^{a}	270.00+7.99^{a}	276.25+11.25^{a}	260.63+1.65^{a}	226.25+4.51^{b}	248.54+38.63^{ab}
Total poly-phenol	12	32.81 + 0.12^{c}	32.65+0.33^{c}	38.92+0.32^{b}	33.19+0.85^{c}	40.04+0.79^{a}	40.30+0.77^{a}
	16	36.24 + 1.31^{bc}	37.57+0.24^{b}	41.99+0.82^{a}	37.07+0.30^{b}	34.90+0.64^{c}	36.83+1.58^{b}
Beta-caro-tene Flesh	12	198.24 + 0.55^{c}	201.28 +3.47^{bc}	184.31+0.93^{d}	184.47+1.73^{d}	335.47+1.69^{a}	204.16+6.46^{b}
	16	195.84 + 4.41^{bc}	193.11+0.97^{c}	189.11+2.17^{d}	216.97+0.28^{a}	192.40+1.47^{cd}	199.04+0.74^{b}
Beta-caro-tene Peel	12	382.71 + 3.09^{a}	386.39+3.85^{a}	323.67+9.17^{d}	370.86+5.83^{b}	380.14+1.47^{a}	347.47+3.85^{c}
	16	347.00 + 3.61^{a}	342.99+2.68^{ab}	337.87+2.82^{b}	336.11+7.90^{b}	340.11+5.66^{ab}	347.16+2.00^{a}

Values are means + standard deviation triplicates determination. Means bearing with different superscripts in the same row are significantly [*P<0.05*] different. US_1 = Umuspo1 planted at 20 cm, ES_1 = Ex-Onyunga Planted at 20 cm, US_2 = Umuspo1 planted at 30 cm, ES_2 = Ex-Onyunga planted at 30 cm, US_3 = Umuspo1 Planted at 40 cm, ES_3 = Ex- Onyunga planted at 40 cm, MP = Maturity Period, WK = Weeks.

6.1. Flavonoid Content at 12 Weeks

The flavonoid content of the Ex-Onyunga OFSP varieties planted at 20 cm, 30 cm and 40 cm at 12 weeks recorded the concentrations of 283.54 µg/g, 288.33 µg/g and 291.88 µg/g, respectively, and the Umuspo1 OFSP varieties planted at 20 cm, 30 cm and 40 cm at 12 weeks also recorded the concentrations of 263.13 µg/g, 268.33 µg/g and 275.21 µg/g, respectively. Flavonoid content of Ex-Onyunga OFSP variety planted at 40 cm spacing distance was significantly *(P<0.05)* higher than that of Umuspo1 OFSP variety planted at 30 cm spacing distance. Flavonoids are important antioxidants and promote health. Aside from antioxidants activity, these molecules provide the following beneficial effects: anti-viral, anti-cancer, anti-inflammatory and anti-allergic. Quercetin, a naturally occurring flavonoid, has been reported to possess anti-flammatory and anti-allergic properties and may be beneficial in the management of allergic conditions such as asthma, hay-fever (allergic rhinitis), and eczema [13, 27].

The results of flavonoid content obtained from this study are comparable to the results reported by [14] that ranged from 200 µg/g to 300 µg/g. The flavonoids, in abundance, were reported to be catechin, epicatechin, erodictyol, kaempeferol and naringenin [15].

6.2. Flavonoid Content at 16 Weeks

The flavonoid content of Umuspo1 OFSP varieties with the distance spacing of 20 cm, 30 cm and 40 cm had concentrations 268.54 µg/g, 270.00 µg/g and 276.25 µg/g, respectively, while Ex-Onyunga of OFSP varieties with the distance spacing of 20 cm, 30 cm and 40 cm had the concentrations of 260.63 µg/g, 226.25 µg/g and 248.54 µg/g, respectively. The result showed that Umuspo1 varieties with the concentrations [248.54 µg/g, 270.00 µg/g and 276.25 µg/g] µg/g and Ex Onyunga varieties with the concentrations [260.63 µg/g and 248.54 µg/g] had no significant *(P>0.05)* differences among them, but they are significantly *[P<0.05]* different from Ex-Onyunga OFSP variety planted at 30 cm with the value of 226.25 µg/g recorded. Flavonoid content is an important anti-oxidant. It helps in promoting several health effects such as hay, fever, eczema, asthma, etc.

6.3. Total Polyphenol Content at 12 Weeks Maturity Period

The total polyphenol content of the Ex-Onyunga OFSP variety planted at 40 cm had the highest concentration of 40.30 µg/g significantly *[P<0.05]* different from other samples. There was no significant *[P>0.05]* difference in the total polyphenol content of Ex-Onyunga OFSP planted at 30 cm and 40 cm. The total polyphenol content of Umuspo1 planted at 40 cm spacing had significantly *[P<0.05]* different higher than other samples. The total polyphenol content of the Ex-Onyunga variety planted at 20 cm, and Umuspo1 varieties planted at 20 cm and 30 cm were lower than every other sample. Total polyphenols are the most abundant antioxidants in the human diet. Epidemiological, clinical and animal studies support their roles in the prevention of various chronic diseases [16].

6.4. Flavonoid Content at 16 Weeks

The flavonoid content of Umuspo1 OFSP variety with the distance spacing of 20 cm, 30 cm and 40 cm had concentrations of 268.50 µg/g and 276.25 ug/g, respectively, while Ex-Onyunga OFSP variety with the same distance spacing stated above had the concentrations of 260.63 ug/g, 226.25 µg/g and 248.54 µg/g, respectively. The results showed that Umuspo1 variety of OFSP with the concentrations [260.63 and 248.54] µg/g had no significant *[P>0.05]* differences among them but they are significantly [P<0.05] different from Ex-Onyunga OFSP variety planted at 30 cm with the value of 226.25 µg/g recorded.

6.5. Total Polyphenol Content at 16 Weeks

The total polyphenol content of Umuspo1 OFSP variety with the distance spacing of 40 cm had the highest value [41.99 µg/g], and significantly *[P<0.05]* different from the total polyphenol content of all other samples. While Ex-Onyunga OFSP variety planted at 20 cm had a value of 37.07 + 0.30 ug/100g and 40 cm had a value of 36.83 + 1.58 ug/100g, Umuspo1 OFSP variety planted at 20 cm had a value of 36.24 + 1.31 ug/100g, and 30 cm had a value of 37.57 + 0.24 ug/100g, respectively, were recorded as the second highest concentrations observed with no significant *[P>0.05]* differences between them. Total polyphenol is the most abundant antioxidant in the human diet and epidemiological, clinical and animal studies support their roles in the prevention of various chronic diseases [16].

6.6. Beta-Carotene of Edible Portion Content at 12 Weeks

The Beta-Carotene content of Ex-Onyunga OFSP with a spacing of 30 cm had the highest concentration [335.47 µg/g] and was significantly *[P>0.05]* different from the Beta-carotene content of all other samples. While the Beta-carotene content of Ex-Onyunga OFSP planted at 20 cm with the concentration [184.47 µg/g], and Umuspo1 OFSP planted at 40 cm with the concentration [184.31 µg/g] had no significant difference *[P>0.05]*, and they were observed as the lowest edible portion of Beta-carotene content. These mentioned concentrations or values are lower than the concentrations reported by [17] and [18], who reported that the Beta-Carotene content of OFSP variety ranged from 4619 µg/g to 4889µg/g. The differences observed were due to planting spaces adopted in this study. The findings support the 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 [19, 20].

6.7. Beta-Carotene of the Edible Portion Content at 16 Weeks

The Beta-carotene content of the edible portion of Ex-Onyunga OFSP variety with spacing distance of 20 cm had the highest value [216.97µg/g] and significantly *[P<0.05]* different from Beta-carotene content of all other samples. The Ex-Onyunga OFSP varieties planted at 30 cm and 40 cm and Umuspo1 OFSP varieties planted at 30 cm and had no significant *[P>0.05]* difference, and they were observed to possess the lowest content of Beta-carotene. These values are lower than the values reported by [17] and [18], who reported that the Beta-carotene content in the county variety of OFSP ranged from 4619 ug/100g to 4889 ug/100g. These differences observed could be a county variety of sweet potato attributed to different planting spaces adopted in this study.

6.8. Beta-Carotene of the Peel Content at 12 Weeks

Beta-carotene of the peel of Ex-Onyunga OFSP variety planted at 30 cm distance apart with a concentration of 380.14µg/g and Umuspo1 OFSP variety of distance spacing of 20 cm and 30 cm with the concentration ranged from 382.71µg/g to 386.39 µg/g recorded as the highest concentration of Beta carotene content in peels sample among all other samples with no significant *[P<0.05]* different, while Ex-Onyunga OFSP variety with a planting spaces of 20 cm was observed as the second highest concentration of Beta-carotene content higher than Umuspo1 OFSP variety. The lowest Beta-carotene concentration was observed in the Umuspo1 OFSP variety planted at a distance of 40cm. This value was lower than the values reported by [17] and [18], who reported that the beta-carotene content in the county variety of OFSP ranged from 4619 ug/100g to 4889 ug/100g. These differences observed could be attributed to differences in planting spaces adopted in this study. Beta-carotene has been used to reduce the risk of breast cancer in women before menopause and the risk of aged-related macular degeneration (AMD) [21]. It is also used to decrease asthma symptoms, to prevent certain cancers, heart-disease, cataracts and to treat AIDS; Alcoholism, Alzheimer's disease, depression, epilepsy, headache, heart burn, high blood pressure, infertility, parkinson's diseases, rheumatoid arthritis, schizophrenia, and skin disorder including psoriasis and vitiliso [17].

6.9. Beta-Carotene of the Peel at 16 Weeks

Beta-carotene of the peels of Ex-Onyunga OFSP variety planted at 40 cm spacing with the highest recorded value [347.16ug/g]. There was no significant *[P>0.05]* difference from other samples. The mentioned value was lower than the values reported by [17] and [18], who reported that the Beta-carotene peels content in the country variety of Sweet Potatoes ranged from 4619 ug/100g to 4889 ug/100g. This difference observed may be due to differences in planting spaces adopted in this research work. Beta-carotene content can be used in malnourished women to reduce day and night blindness during pregnancy as well as diarrhea and fever after giving birth.

Table 2 shows the calculated retinol equivalent of two OFSP varieties [Umuspo1 and Ex-Onyunga] at different spacing distances. The *trans-β*-carotene of Umuspo1 and Ex-Onyunga OFSP had the highest values ranged from 11.79 μg/g to 146.20 μg/g. Among the samples analyzed, the Umuspo1 (US_2) variety of OFSP planted at 30 cm exhibited the lowest concentrations of both carotenoids. Specifically, its 13-cis carotene content was 0.72 µg/g, while the 9-cis carotene content was 0.34 µg/g, both values being lower than those recorded for all other varieties and planting distances.

***Table 2.** The Retinol Equivalent of OFSP [Umuspo1 and Ex-Onyunga] varieties from the carotenoid contents.*

Samples	13-cis-β-carotene [$\mu g/g$]	Trans-β-carotene [$\mu g/g$]	9-cis-β-carotene [$\mu g/g$]
US_1	1.93	39.29	1.48
ES_1	3.73	146.20	2.48
US_2	0.72	11.79	0.34
ES_2	3.53	123.80	2.20
US_3	1.03	15.12	0.76
ES_3	3.44	132.34	2.29

US_1 = Umuspo1 planted at 20 cm, US_2 = Umuspo1 planted at 30 cm, US_3 = Umuspo1 planted at 40 cm, ES_1 = Ex-Onyunga Planted at 20 cm, ES_2 = Ex-Onyunga planted at 30 cm, ES_3 = Ex- Onyunga planted at 40 cm.

7. Conclusion

Among the roots and tuber crops grown in the world, OFSP ranks second after cassava [22]. The carbohydrate rich root is used as a subsidiary food boiling/baking. This tuber crop provides food for most of the world's population, occupying the position of the seventh most important food crop in the world by the beginning of the 21st century [23]. It has been shown to act as an immune modulator, quench singlet oxygen, and reduce peroxyl radicals at a low partial oxygen pressure [24]. Overall, the beta-carotene content of Ex-Onyunga (ES_3) peel at 12 weeks, planted at 40 cm spacing, recorded the highest value of 347.47 µg/g, whereas the beta-carotene content of Ex-Onyunga (ES_3) flesh under the same conditions recorded the lowest value of 204.16 µg/g. Similarly, at 16 weeks, the peel of Ex-Onyunga (ES_3) planted at 40 cm spacing exhibited a slightly lower but still high beta-carotene content of 347.16 µg/g, while the flesh recorded a value of 199.04 µg/g, representing the lowest concentration among the sampled tissues at this stage.

Abbreviations

ANOVA	Analysis of Variance
AIDS	Acquired Immune Deficiency Syndrome
AMD	Aged-related Macular Degeneration
DPPH	Dipenyl-2-picrylhydrazyl
ES1	Ex-Onyunga Planted at 20 cm
ES2	Ex-Onyunga Planted at 30 cm
ES3	Ex-Onyunga Planted at 40 cm
K	Potassium
MP	Maturity Period
N	Nitrogen
OFSP	Orange Fleshed Sweet Potatoes
P	Phosphorous
RCBD	Randomized Complete Block Design
SPSS	Statistical Package for Social Science
US1	Umuspo1 Planted at 20 cm
US2	Umuspo1 Planted at 30 cm
US3	Umuspo1 Planted at 40 cm
WK	Weeks

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Author Contributions

Linus Slyvester Ndah: Conceptualization, Resources, Original draft, writing - review and editing, Data curation, Formal Analysis supervisor, Methodology

Iniobong Enefiok Udoh: Formal Analysis supervisor, Investigation, Visualization, Writing review - editing, Methodology

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Conflicts of Interest

The authors declare no conflicts of interest.

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