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Studies on keeping quality and proximate composition of different orange fleshed sweet potato (*Ipomoea batatas* L.) genotypes under ambient storage

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Abstract
Sweet potato is positioned as the sixth most major food crop in the world, fourth in tropical countries and fifth most essential food crop on a fresh weight basis in developing countries after rice, wheat, maize and cassava. Orange fleshed sweet potato (OFSP), in particular produces storage roots rich in β-carotene, a precursor of Vitamin A. Therefore, OFSP is a promising genotype to address the Vitamin A deficiency needs of women & children and to prevent malnutrition in poverty & tribal areas. However, sweet potatoes face the problem of weevils, shrinkage and loss of nutrients in storage. Therefore, present research on shelf-life and physicochemical parameters of 7 different orange sweet potato genotypes were studied in order to determine the varieties for better storage. Among those, the genotype HUB-66 was found best with lowest firmness on all the days of observation, minimum loss in PLW and volume at the end of the storage by exhibiting higher shelf life of 12 days. Highest beta carotene content was found in the genotype ST-14 (13.23 mg/100g) with *L* a* b** values 78.58. 1.29 and 7.96 respectively. Lowest per cent of weevil incidence was noticed in TSP16-3 on 4 and 8 DAS (5.05 and 13.20% respectively).

Keywords: Keeping quality, ambient, proximate composition, genotypes and shelf life

Introduction
The sweet potato (*Ipomoea batatas* L.) is a semi-perishable commodity. Appropriate and efficient post harvest technology and marketing are critical to the entire production-consumption system of sweet potato because of its bulkiness and perishability. The purpose of storage is to maintain tubers in marketable condition and to provide a uniform flow of tubers to market and processing plants throughout the year. It must be realized that storage losses cannot be avoided even by optimal storage (Maldegem, 1999) [14]. Storage losses are mainly caused by the processes like respiration, weevil incidence, sprouting, and evaporation of water from the tubers, spread of diseases, changes in the chemical composition and physical properties of the tuber and damage by extreme temperatures (Prathiksha and Naik, 2019a) [22].
Sweet potato varieties exist in many colours of skin and flesh, ranging from white to deep purple, although white and yellow orange flesh are the most common (Prathiksha and Naik, 2019a; Sharavathi *et al.*, 2018; Adam, 2005) [22, 25, 2]. The sweet potato varieties grown by farmers in sub-saharan Africa including Nigeria have white or cream flesh, which contain little or no beta-carotene (Stathers *et al.*, 2005) [29]. The carbohydrate content of the sweet potato tubers varies from 25 to 30 per cent, while the rest is composed of water (58% to 72%). Sweet potatoes are good sources of vitamin C, vitamin E, dietary fibre, calcium, potassium and iron, and are low in fat and cholesterol. However they also contain moderate quantities of thiamine (B_1), riboflavin (B_2), niacin, pantothenic acid (B_5), pyridoxine (B_6) and folic acid. Moderate quantities of sodium, magnesium, manganese and zinc are also present. Significant variation in quality parameters among different genotypes of sweet potato might be due to the inherent genetic makeup of the genotype and influence of environmental conditions (Sharavathi *et al.*, 2018) [25].
The main objective of present study was to test efficiency of different sweet potato genotypes for retention of processing qualities under ambient storage conditions.

Materials and Methods
The present investigation was carried out in northern dry zone (Zone-3) of Karnataka state at 16°15' north latitude, 74°45' east longitudes and at an altitude of 612.05 m above the mean sea level, in the laboratory of the Department of Postharvest Technology, Kittur Rani Channamma

College of Horticulture (University of Horticultural Sciences, Bagalkot), Arabhavi, Gokak Taluk and Belgaum district of Karnataka state during the period from 2018-19.

Selection and preparation of sweet potatoes for experiments

Even sized fresh sweet potatoes tuber representative of different varieties were procured from the research field of AICRP on tuber crops, operating at Regional Horticulture Research and Extension Centre, Dharwad of Karnataka state. Uniform mature tubers free from pest and disease infestation were selected. Procured sweet potatoes were washed under running tap water to remove adhered soil. Damaged and infected tubers were discarded and good tubers were surface dried under shade.

Total soluble salts (°Brix)

The total soluble solids (TSS) of the sweet potato genotypes were estimated using the hand refractometer on the different days of observation. A small amount of the flesh of tuber was crushed using mortar-pestle and its juice was obtained by filtering it using multiple layers of muslin cloth. The obtained clear juice was applied in drops on the prism of the calibrated refractometer and the values were read.

Beta-carotene content (mg/100g)

Beta-carotene present in sweet potato tubers was estimated by using petroleum ether method.

Dry matter content (%)

Dry matter content of sweet potato tubers was determined by drying the finely sliced piece of tuber in microwave oven (Onida Power Barbecue-28, MIRC Electronics ltd., Mumbai) at 40 and 60 power intensity until the constant weight was achieved. The dry weight was calculated using the following formula.

$$\text{Dry matter content (\%)} = \frac{W_2}{W_1} \times 100$$

Where,

W_1 = Fresh weight of the tubers

W_2 = Dry weight of the tubers

Total sugars (%)

The total sugar content in the products were estimated by the same method as in case of reducing sugar after inversion of the non-reducing sugar using dilute hydrochloric acid.

The per cent reducing sugars present in sweet potato tubers were estimated using 3, 5-Dinitro Salicylic Acid (DNSA) method (Miller, 1972) [19]. The values obtained are expressed as per cent.

$$\text{Reducing sugars (\%)} = \frac{\text{Value from graph x volume of alcohol free extract}}{\text{Aliquot sample used x weight of sample}} \times 1000$$

Starch (%)

Starch content in sweet potato tubers was estimated by anthrone reagent method. The sample was treated with 80 per cent alcohol to remove sugars and then starch was extracted with perchloric acid (52%). In hot acidic medium starch was hydrolyzed to glucose and dehydrated to hydroxylmethyl furfural, this compound forms a green coloured product with anthrone (Bates *et al.*, 1943) [6].

Ascorbic acid content (mg/100g)

Ascorbic acid content of sweet potato tubers was estimated by using the method given by AOAC (1990) [5], which was based on the reduction of 2,6-dichlorophenol indophenols (2,6-DCPIP) by ascorbate.

Total titratable acidity (%)

The total titratable acidity of sweet potato was estimated by titrating the sample against strong base i.e. NaOH.

Physiological loss in weight (%)

The physiological loss in weight (PLW) was estimated at an interval of 4 days during storage. Initial tuber weight was recorded at the beginning of the storage period. The tubers were weighed and the weight was termed as final weight on the particular date of observation. Formula suggested by Srivastava and Kumar (1997) [28] was employed to calculate the PLW for each date of observation.

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Volume (%)

The volumes of the tubers were calculated at 4 days intervals by randomly selected and marked tuber from replication. For this, two containers of different sizes were used. The smaller container was filled with water up to the brim such that, any further addition of water would spill it out of the container. Then the marked tuber was gently dipped in the water keeping the smaller container inside the bigger one, which led to displacement of water from the small container and it was equal to the volume of the tuber (based on Archimedes principle). The spilled out water from the larger container was then measured using a measuring cylinder and it was expressed as volume of the tuber.

$$\text{Volume (\%)} = \frac{\text{Initial volume} - \text{Final volume}}{\text{Initial volume}} \times 100$$

Results and Discussion

The observations on different parameters of orange fleshed sweet potato genotypes stored in ambient condition are discussed below.

Total soluble solids (°Brix) and Total Sugars (%)

In present investigation, the total sugars of sweet potato tubers increased continuously up to the end of the experiment (table 1). Accumulation of total sugars could be attributed to the dormancy release and onset of sprouting as thereafter the cultivars showed sprouting, which continued to increase up to the end of experiment (Abdullah and Safraiy, 2015) [1]. Maximum value for TSS was recorded in TSP16-10 at initial, 4th and 8th DAS (7.23, 7.29 and 7.30°Brix respectively). It was directly related to the presence and conversion of starch to sugars. Highest total sugar content (2.86%) was found in TSP16-10 initially, while on 4 and 8 DAS, it was found highest in TSP16-7 (2.90 and 3.20% respectively). Increase in total sugar content might be due to breakdown of starch into sugars and increase in total sugar content directly responsible for higher TSS during storage. Similar results were cited by Agbemafle *et al.* (2014) [3] in potato, Sharavati *et al.* (2018) [25] Prathiksha and Naik (2019a) [22] in sweet potato.

Beta-carotene (mg/100g)

Beta-carotene is sensitive to heat and oxygen as opined by Emmanuel *et al.* (2010) [11]. Oxidation of carotenoids results in the loss of beta-carotene in the fruits and vegetables as reported by Shekhar *et al.* (2015) [26]. In the present investigation, the highest beta-carotene was maintained in the genotype ST-14 at initial, 4 and 8 DAS (13.2 13.03 and 12.43 mg/100g respectively). TSP16-7 had found to be next to ST-14 by maintaining second highest content of beta-carotene content of 7.07, 6.73 and 6.17 mg/100g at all the observations during storage (table 3). This variation occurred due to the difference in flesh colours which was genotype dependent factor (Blessington *et al.* 2010, Desai *et al.*, 2013) [7, 9]. Similar results were recorded by Prathiksha and Naik (2019a) [22] and Sharavathi *et al.* (2018) [25] in sweet potato.

Dry matter content (%)

The dry matter in the tubers increases during storage. However the amount of increase in dry matter content varies among the genotypes (Prathiksha and Naik 2019a; Ellong *et al.*, 2014; Nabubuya *et al.*, 2012 and Ezekiel and Rani, 2006) [22, 10, 20, 12] in sweet potatoes. In the present investigation, the highest dry matter was observed in the genotype TSP16-7 on initial, 4th and 8th 4 DAS (32.50, 38.83 and 41.83% respectively). The increased dry matter content during the storage period could be attributed to the increase in chemical constituents and also decrease in the moisture content of the tubers. These results are in conformity with the findings of Prathiksha and Naik (2019a) [22], Mehta and Kaul (1990) [17], Serge and Tom (1996) [24], Agbemafle *et al.* (2014) [3] in sweet potato and Patel *et al.* (2018) [21] in cassava.

Starch (%)

Amount of starch in different varieties is a character which varies with genotype and different chemical constituents in the tubers as quoted by Zhang *et al.* (2002) [30]. In the present investigation, the maximum amount of starch was recorded in TSP16-7 (23.92%) initially and same genotype had maximum of 21.50 and 19.33 per cent starch respectively on 4 and 8 days of storage (table 8). Starch content of sweet potato tubers, which is indeed a varietal trait, slightly decreased during storage. The decline in starch content was correlated with α-amylase activity in storage. There was a stronger positive and significant correlation between starch and reducing sugar content. The reduction in starch was due to the catabolic reactions in storage leading to conversion of complex starch molecules into simpler sugars. Similar reports have also been made by Khayatnezhad *et al.* (2011) [13] Prathiksha (2017) [23] Sharavathi *et al.* (2018) [25] in sweet potato genotypes and Patel *et al.* (2018) [21] in cassava.

Ascorbic acid (mg/100g) and Titratable acidity (%)

The genotypes differ in the amount of ascorbic acid content and titratable acidity as stated by Singh *et al.* (2005) [27] and it decrease on storage in ambient condition. However in the present investigation, the ascorbic acid and titratable acidity content in the tubers decreased in all the genotypes as the storage time progressed (table 3). The maximum amount of ascorbic acid (23.08, 20.63 and 17.53 mg/100g) and titratable acidity (0.29, 0.26 and 0.17%) was recorded in TSP16-10 at all intervals of observations during storage. While minimum ascorbic acid (13.30 mg/100g) content and titratable acidity (13.30%) was recorded in TSP16-7 at initial day of storage. On 8 days after storage minimum titratable acidity was recorded in TSP16-3 (0.12%). Significant decrease in ascorbic acid and titratable acidity noticed, could be due to enzymatic loss of L-ascorbic acid where it is converted to 2-3-dioxy-L-gluconic acid that directly influence the decreased total titratable acidity (Mapson, 1970) [15]. These results were found to be in line with the investigations of Prathiksha and Naik (2019a) [22], Sharavati *et al.* (2018) [25] in sweet potato, Patel *et al.* (2018) [21] in cassava and Brar (2013) [8] in potato.

Physiological loss in weight and loss in volume (%)

The PLW increases with progress in storage period however the values of PLW were genotype dependent factor (Amoah *et al.*, 2011) [4]. In the present study, minimum PLW was recorded in HUB-66 on 4th and 8th DAS (12.44 and 22.60% respectively) It was directly correlated with volume loss and recorded minimum loss in volume on 4th and 8th DAS (16.67 and 32.33 ml respectively). There was a difference in PLW and volume loss among the genotypes of sweet potato tested in the present investigation findings (table 1). This difference in PLW and volume loss might be due to the difference in respiration and transpiration rates in different genotypes and also increase in respiration rate as the storage prolonged (Mehta and Singh, 2002) [18]. These reports were found to be in line with the study by Mehta and Ezekiel (2010) [16] in potato, Sharavati *et al.* (2018) [25] Prathiksha and Naik (2019a) [25] in sweet potato genotypes and Patel *et al.* (2018) [21] in cassava.

Table 1: Effect of storage on total soluble solids, total sugars PLW and volume of tubers of different orange fleshed sweet potato genotypes

Genotypes	TSS (ºB)			Total sugars (%)			PLW (%)		Volume (%)	
	Days after storage									
	Initial	4	8	Initial	4	8	4	8	4	8
TSP16-3	7.10	7.17	7.20	2.82	2.90	3.03	12.67	23.20	17.17	33.30
TSP16-5	6.86	6.93	7.13	2.73	2.83	3.14	16.08	36.30	25.33	52.00
TSP16-6	7.14	7.20	7.23	2.83	2.91	3.03	13.00	27.30	20.33	44.00
TSP16-7	6.80	7.03	7.29	2.70	2.90	3.20	16.00	43.17	27.17	64.17
TSP16-10	7.23	7.29	7.30	2.86	2.89	2.91	13.08	24.13	18.00	34.20
ST- 14	6.65	6.80	6.97	2.53	2.64	2.77	12.87	25.50	18.50	37.83
HUB-66	6.75	6.87	7.03	2.65	2.76	2.84	12.44	22.60	16.67	32.33
Mean	6.93	7.04	7.13	2.73	2.83	2.99	13.73	28.89	20.45	42.83
S.Em±	0.02	0.04	0.05	0.01	0.01	0.04	0.10	0.45	0.30	0.44
C.D. @ 1%	0.078	0.12	0.13	0.05	0.05	0.12	0.31	1.37	0.91	1.35

Table 2: Effect of storage on tuber starch and dry matter content of different orange fleshed sweet potato genotypes

Genotypes	Starch (%)			Dry matter (%)		
	Days after storage					
	0	4	8	0	4	8
TSP16-3	21.34	19.37	18.17	30.50	32.50	35.87
TSP16-5	20.23	18.83	17.17	28.50	35.83	38.03
TSP16-6	20.84	19.03	17.83	27.83	30.50	33.83
TSP16-7	23.92	21.50	19.33	32.50	38.83	41.83
TSP16-10	21.23	20.43	19.10	30.02	32.50	35.83
ST- 14	18.35	17.17	15.33	27.07	32.33	35.33
HUB-66	20.12	18.83	17.73	27.50	31.33	34.17
Mean	20.86	19.31	17.81	29.13	33.40	36.41
S.Em±	0.05	0.21	0.31	0.22	0.33	0.32
C.D. @ 1%	0.15	0.66	0.94	0.69	1.01	0.98

Table 3: Effect of storage on ascorbic acid, total titratable acidity and beta carotene content in tubers of orange fleshed sweet potato genotypes

Genotypes	Ascorbic acid (mg/100g)			Total titratable acidity (%)			Beta carotene (mg/100g)		
	Days after storage								
	Initial	4	8	Initial	4	8	Initial	4	8
TSP16-3	14.80	14.33	10.53	0.23	0.22	0.14	4.03	3.53	3.33
TSP16-5	15.23	9.97	8.10	0.24	0.18	0.12	5.96	5.50	5.17
TSP16-6	22.37	16.80	16.27	0.28	0.21	0.16	5.13	4.83	4.60
TSP16-7	13.30	12.77	8.30	0.21	0.19	0.13	7.07	6.73	6.17
TSP16-10	23.08	20.63	17.53	0.29	0.26	0.17	5.50	5.27	4.83
ST- 14	18.50	13.30	9.97	0.25	0.21	0.13	13.23	13.03	12.43
HUB-66	16.94	15.50	15.17	0.24	0.22	0.16	3.93	3.77	3.37
Mean	17.75	14.76	12.27	0.23	0.20	0.16	6.41	6.10	5.70
S.Em±	0.46	0.32	0.25	0.02	0.03	0.02	0.07	0.17	0.16
C.D. @ 1%	1.40	0.97	0.76	0.08	0.10	0.07	0.21	0.52	0.51

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