Carotenoids, sugars and dry matter concentrations in sweetpotato are different in two Brazilian regions

Alexandre Furtado Silveira Mello[1*], *Adriana Paula da Silva Minguita*[2], *José Luiz Viana de Carvalho*[2], *Manuela Cristina Pessanha de Araújo Santiago*[2], *Sidney Pacheco*[2], *Giovani Olegário da Silva*[1]

10.1590/0034-737X2024710011

ABSTRACT

Considering that the expression of sweetpotato characters may vary according to the environment, we aimed to evaluate the nutritional performance of nine genotypes in two different regions. Experiments were carried out in Itabaiana, SE and Gama, DF, in 2015/2015 and 2015/2016 crop years. The experimental design was a four-replicate randomized block design of 10 plants per row, spaced 75 cm between rows and 40 cm between plants. The treatments were the Beauregard cultivar and eight clones 6, 8, 9, 33, 50, 66, 75, 79; in addition, two local cultivars (Olho Roxo and Ourinhos) were used as controls for sugar analysis. They were evaluated for dry matter, total carotenoid and betacarotene content; and the content of fructose, glucose, sucrose, and total soluble solids. Total and soluble sugars evaluations were performed only in 2015/2016. The resulting data underwent analysis of individual and pool variances, simple correlation, and grouping of treatment means by a Scott-Knott test. It was verified that dry matter, brix, total carotenoids, betacarotene, and sugar (fructose and glucose) levels were different in Itabaiana-SE and Gama-DF evaluations. These findings demonstrate the importance of regional validations of sweetpotato quality traits under different Brazilian conditions.

Keywords: *Ipomoea batatas* (L.) Lam; biofortification; breeding; betacarotene.

INTRODUCTION

The orange color of sweetpotato roots is indicative of the presence of carotenoids, with a prevalence of betacarotene, a precursor of vitamin A in the human body (Low *et al.*, 2017). The antioxidant activity of these compounds and their ability to deactivate free radicals provide some protection against degenerative diseases such as cancer, cardiovascular diseases, cataracts, mucosal protection against gastric ulcers and increased immune response to certain types of infection (Berni *et al.*, 2015; Wiseman *et al.*, 2017).

Vitamin A activity in food is expressed in retinol activity equivalents, and the proportion of food betacarotene reduced to retinol varies according to both the food ingested and the animal species (Berni *et al.*, 2015). Betacarotene may be present in fruits and vegetables either in the *trans* form, which is more stable and better utilizable by the human organism, or as *cis* (9-cis and 13-cis) isomers. According to the FAO, it may be assumed that 33% of the betacarotene present in foods will be available for absorption, and its conversion into vitamin A is 50% for the *trans* form and 25% for *cis* isomers (Rodriguez-Amaya *et al.*, 2008).

The lack of vitamin A in the human body (hypovitaminosis A) and iron deficiency (anemia) are the main nutritional deficiencies that affect the Brazilian population. The 2006 National Survey of Demography and Health of

Submitted on May 16th, 2022 and accepted on November 12th, 2023.
[1] Embrapa Hortaliças, Brasília, DF, Brazil. alexandre.mello@embrapa.br; giovani.olegario@embrapa.br.
[2] Embrapa Agroindústria de Alimentos, Rio de Janeiro, RJ, Brazil. adriana.minguita@embrapa.br; jose.viana@embrapa.br; manuela.santiago@embrapa.br; sidney.pacheco@embrapa.br
*Corresponding author: alexandre.mello@embrapa.br

Children and Women (PNDS) reported that among children under five years of age participating in the study, 20.9% had anemia, 17.4% had hypovitaminosis A, 7.4% were overweight, 6.8% had height deficits and 1.6% had weight deficits.

In view of the potential for betacarotene-rich sweetpotato being broadly adopted by Brazilian producers, and also considering that the expression of phenotypic characters may vary according to the environment, we sought to evaluate the performance of different sweetpotato breeding clones and one cultivar, grown in two different Brazilian regions, for root quality characters.

MATERIALS AND METHODS

Four experiments were carried out, each using eight bud seedlings, three of which were buried in soil. Seedlings were produced in a meristem tissue culture laboratory, tested for viruses in an *Ipomoea setosa* indicator plant, and then replicated in a screen house to reduce the possibility of virus transmission. Experiments were performed in Itabaiana, SE and Gama, DF (Table 1). No climatic abnormalities such as droughts, hail, frosts, or significant pest attacks were detected in any of the locations. In experiments performed at the Gama-DF location, pre-planting fertilization included P_2O_5 (196.8 kg ha^{-1}), Ca (76.8 kg ha^{-1}) and K_2O (58 kg ha^{-1}), using triple superphosphate and KCl. Weed control was performed 30 days after planting followed by the application of 30 kg ha^{-1} of N as calcium nitrate. At the Itabaiana, SE location, where the experimental area was managed under organic conditions, the same rate of nitrogen was applied in the form of castor–bean cake, a residue generated during the extraction of oil from castor beans.

One commercial orange flesh sweetpotato (OFSP) cultivar, Beauregard and eight experimental clones 6, 8, 9, 33, 50, 66, 75, 79 were evaluated in two site locations (Gama-DF and Itabaiana-SE). Clone 9 is white-fleshed, while the other seven clones are OFSP. In addition, two white-fleshed local cultivars (Olho Roxo and Ourinhos) were used as controls for sugar analysis. Experiments at both the Gama-DF and Itabaiana-SE locations were performed in two separate seasons (one summer and one winter) (Table 1).

The experimental design was a four-replicate randomized block design, and the experimental plots included 10 plants per row, spaced 75 cm between rows and 40 cm between plants (3.00 m^2). An external edge row in each block was included but not evaluated.

Roots were harvested and three 200-g roots were pooled as one composite sample from each of the four block replicates. Each pool of roots, representing one replication of each block, was used to determine each of the following quality character: dry matter content, expressed as a percentage; total carotenoid content and betacarotene expressed in mg kg^{-1}; and the content of fructose, glucose and sucrose, expressed as g 100 g^{-1}. Total soluble solids were evaluated with a refractometer and measured in ºBrix. Soluble sugars and Brix evaluations were performed only on the summer samples.

Dry matter content (DM) was determined based on the gravimetric method (Horwitz & Latimer, 2010). For the first weight evaluation the oven air circulation was at 105 °C for five uninterrupted hours; then weights were checked hourly until root weights were constant.

Carotenoid extraction was done at room temperature (20–25 ºC)(Rodriguez-Amaya *et al.*, 2008). All analyses were performed in triplicate. About 2 to 5 g of each of the samples were weighed and then manually macerated in a mortar and pestle with 3 g of celite and 50 mL of cold acetone. The mixture was vacuum filtered in a 250mL glass funnel with a sintered plate with porosity number 4. The extraction procedure was repeated four times, after which the sample had no remaining carotenoid characteristic color. The acetone extract was transferred to a separatory funnel with 50 mL of petroleum ether and then washed at least three times with 300 mL of ultrapure water. The ether extract was filtered through anhydrous sodium sul-

Table 1: Soil, site location coordinates, planting, harvesting dates and site altitudes

Site Location	Soil*	Planting	Harvesting	Coordinates		Altitude (m)
Gama W	Cambisol	30 Mar 2015	04 Aug 2015	15°56'3.19" S	48°8'12.00" W	990
Itabaiana S	Leptosol	09 Apr 2015	18 Aug 2015	10°40.515' S	37°21.917' W	159
Gama S	Cambisol	03 Dec 2015	13 Apr 2016	15°56'3.19" S	48°8'12.00" W	990
Itabaiana W	Leptosol	27 Nov 2015	29 Mar 2016	10°40.515' S	37°21.917' W	159

W. winter trial, S. summer trial.*(Santos *et al*., 2018).

fate, collected in 100 mL volumetric flasks and completed with petroleum ether. The level of total carotenoids in the sample extracts was determined by spectrophotometry at 450 nm on a Shimadzu UV-1800 using betacarotene molar absorptivity.

Carotenoid profiles were determined by transferring a 1 mL aliquot of the sample extract into an amber flask, drying it in an N_2 stream and then dissolving it in 100 mL of acetone. The carotenoid profiles were determined in an acetone extract using a Waters TM HPLC system, controlled by the Empower-software program (Waters TM), with the column oven at 33 °C and photodiode detection (PDA) (Pacheco *et al.*, 2014). Carotenoid separation was obtained on a YMC column (S-3 carotenoids, 4.6 mm x 250 mm, YMC™) by gradient elution of methanol and methyl tert-butyl ether. Elution started with a mixture of 80% methanol and 20% methyl tert-butyl ether. At 0.5 min the ether concentration was increased to 25%, at 15 min to 85% and at 15.0 to 90% ether. The ether concentration was maintained at 90% until 16.50 min and then, at 16.55 min, returned to the initial condition (20%), and kept constant until 28 min.

The flow rate was 0.8 mL min^{-1} while the running time was 28 min. Sample injection volume was 15 µL. Carotenoid identification and quantification was done using an analytical curve developed by Embrapa Food Technology and a process previously described (Tiburski *et al.*, 2011).

Sugars were extracted using 1 g of sample and ultrapure water in an ultrasonic bath for 20 minutes, followed by the addition of 5 mL of acetonitrile (Macrae, 1998). The resulting extract was filtered and analyzed on a high-performance liquid chromatograph (Waters Alliance 2690/5), employing a refractive index detector Waters model 2410. The data were analyzed using Empower software. A 30 cm x 4.6 mm ZORBAX Carbohydrate Agilent column was used with the following parameters: flow of 1.0 $mL.min^{-1}$, injection volume of 20 µL, isocratic elution mode with an acetonitrile mobile phase: water (75:25 v/v) and time of 20 minutes. Analyses were performed in triplicate. Fructose, glucose and sucrose were quantified by external standards with a retention time of 6.93, 7.52 and 9.66 min respectively, based on calibration curves with a range of concentration from 1.2 to 5.0 mg mL^{-1}, made with commercial analytical standards of fructose, glucose and sucrose.

The resulting data underwent analysis of individual and pool variances, simple correlation, and grouping of treatment means by a Scott-Knott test at 5% probability, using the statistical software GENES (Cruz, 2016). It was also estimated the coefficient of environmental variation (CVe) and coefficient of genetic variation (CVg), by the formulas CVe = $100\sqrt{QMe / mean}$ and CVg = $100\sqrt{\hat{\sigma}_g / mean}$, respectively, were *QMe* = error square means and $\hat{\sigma}_g$ = genetic variance, obtained according (Cruz *et al.*, 2014).

RESULTS AND DISCUSSION

The analysis of pool variances did not detect triple interaction of genotype, site location and season (Table 2). The eight different OFSP genotypes presented high total carotenoid content in the four different experiments performed (Table 3). The average betacarotene content of the eight OFSP genotypes collected from the Gama-DF and Itabaiana-SE sites were 113 and 99 mg Kg^{-1} respectively. All genotypes except clone 8 had higher betacarotene levels when grown at the Gama-DF site than at Itabaiana-SE (Table 3).

Betacarotene was the predominant carotenoid representing on average, 86.5% of the carotenoids present in the sweetpotato roots. Independent of site location, clone 75 had the highest betacarotene level of the eight genotypes evaluated (Table 3). Clone 6 and Beauregard were consistently the two genotypes with the lowest betacarotene concentration among the genotypes evaluated. The values obtained for Beauregard on the current study are lower than those obtained on previous study that found an average of 120 mg of total carotenoids and 114 mg of betacarotene kg^{-1} in sweetpotato fresh roots (Berni *et al.*, 2015).

Betacarotene variability within different locations and different planting seasons, reported here, were similar to that observed with other sweetpotato clones in other experiments (Manrique & Hermann, 2000). A previous report evaluated nine sweetpotato clones in four different locations in Peru at altitudes ranging from 32 to 1800 meters (Manrique & Hermann, 2000). The two sweetpotato clones having the highest betacarotene content across the four site locations also had great variability of betacarotene levels within the site locations. The difference from the higher betacarotene-site value to the lower one was 1.85 and three-fold for the top two sweetpotato clones respectively. In the present study the majority of the genotypes presented higher betacarotene levels at the Gama-DF site, at 990 m above sea level, than at Itabaiana-SE at 159 m above sea level. The exception was clone 8. However, different from the previous study, the difference among betacarotene levels within site locations for all genotypes ranged from 0 to 60%, values much smaller than the ones presented by

Table 2: Summary of pool analysis of variance for root quality variables evaluated in sweetpotato genotypes in two different regions and seasons for carotenoids and dry matter content, and two regions in one season for brix and sugar content

Source of Variation	Total Carotenoid mg kg^{-1}	Betacarotene mg kg^{-1}	Dry Matter (%)	Brix	Fructose g 100g^{-1}	Glucose g 100g^{-1}	Sucrose g 100g^{-1}	Total sugars g 100g^{-1}
Genotype (G)	9202.98*	7095.45*	300.51*	17.85*	0.27*	0.42*	3.81*	2.21*
Site Location (SL)	10559.67*	6206.37*	107.73*	5.40	1.37*	2.18*	49.52*	17.23*
Season (Sn)	15.12	68.01	28.24	-	-	-	-	-
G x SL	3178.65*	2559.35*	16.96*	3.45*	0.15*	0.22*	0.58	0.88
G x Sn	550.62	441.19	8.67	-	-	-	-	-
SL x Sn	12328.42*	12886.14*	151.89*	-	-	-	-	-
G x SL x Sn	959.92	773.88	13.15	-	-	-	-	-
Residue	299.30	236.57	4.29	0.47	0.04	0.05	0.33	0.39
General mean	122.86	105.98	28.27	12.05	0.61	0.84	4.12	5.54
CV (%)	14.08	14.51	7.32	5.70	33.67	27.76	14.10	11.38
CVg/CV	1.36	1.34	2.08	2.14	0.82	0.92	1.13	0.75

*Significant at 5% probability by F test, CV%: coefficient of environmental variation as a percentage; CVg/CV: rate between the coefficient of genetic and environmental variation, - data not available.

other authors (Manrique & Hermann, 2000). This finding demonstrates that the genotypes evaluated in this study have a consistent betacarotene content under different environmental conditions.

Assuming, according to the methodology employed by FAO, that 33% of the betacarotene will be available for absorption, 50% of which would be changed into vitamin A in the *trans* form, the conversion would be 16.5% (Rodriguez-Amaya *et al.*, 2008). In Brazil, the recommended daily intake is 600 µg retinol (vitamin A) for adults, for infants: 0-6 months – 375 µg; 7-11 months – 400 µg; for children: 1-3 years old – 400 µg; 4-6 years old – 450 µg; 7-10 years old – 500 µg (Anvisa, 2005). Considering also the intake of betacarotene exclusively from this source (sweetpotato). For the betacarotene in Beauregard planted in Itabaiana-SE (Table 3), the intake of 43.5 g of roots per day would satisfy the daily need for adults. However, only 25.6 g per day would be needed to meet the need for adults if clone 75, cropped in the same site location, was consumed.

Dry matter content of sweetpotato roots ranged from 20.7 to 37.8% (Table 4). Considering that Olho Roxo, Ourinhos and Clone 9 are white-fleshed sweetpotatoes, clones 8, 33 and 75 were the OFSP having the highest DM

Table 3: Total carotenoids and betacarotene content from roots of eight sweetpotato genotypes evaluated in two different Brazilian regions

Genotypes	Total Carotenoids µg g^{-1}		Betacarotene µg g^{-1}	
	Gama-DF	Itabaiana-SE	Gama-DF	Itabaiana-SE
6	109.0 cA	79.8 cB	95.9 cA	70.8 cB
8	116.8 cB	143.6 aA	98.94cB	125. 6aA
33	133.5 bA	125.7 bA	110.0 bA	109.2 bA
50	140.5 bA	93.1 cB	120.6 bA	80.1 cB
66	107.1 cA	119.4 bA	91.1 cA	103.4 bA
75	185.6 aA	163.1 aA	163.7 aA	141.9 aA
79	148.0 bA	91.2 cB	124.2 bA	77.5 cB
Beauregard	114.4 cA	94.4 cA	99.1 cA	83.6 cA

*Means with different lowercase letters within the column and uppercase letters within lines are $p < 0.05$ according Scott-Knott and t tests, respectively. Data from Gama-DF and Itabaiana-SE is the mean of two independent experiments with four replicates on each trial.

(Table 4). DM is of great importance since the majority of the consumers in Brazil prefer roots that retain firmness after boiling (Truong *et al.*, 2018). In addition, this characteristic favorably impacts industrial processes such as frying and dehydration. Cultivars with low DM have its acceptance restricted in the fresh market and usually have to be processed to have better acceptance (Santos *et al.*, 2021). The DM content obtained in the current study for Beauregard is similar to that found in the first report of the cultivar (Rolston *et al.*, 1987).

A previous study showed that DM can be influenced by site location in OFSP (Kathabwalika *et al.*, 2013); however, the current study demonstrated that the OFSP genotypes sustain their DM characteristics independent of the site evaluated. However, this trait was not similarly stable on the white flesh genotypes clone 9, Olho Roxo and Ourinhos (Table 4).

For Itabaiana-SE, the mean data are shown as the average of the two seasons, winter (W) and summer (S), for total carotenoids and betacarotene, because there was no significant effect of the planting season or the interaction among genotypes and planting season. The same was true for sucrose for Gama-DF summer and winter crop seasons (Tables 4 and 5).

Sugar content is an attribute for sweetpotato acceptance in many countries (Laurie, 2013). Refraction is commonly used to asses soluble plant carbohydrates using refractometers. In the current study, site location directly influenced carbohydrate concentration. Seven of the 11 sweetpotato genotypes performed distinctively across the two site locations; only clones 33 and 75 had high brix concentration in both site locations (Table 4).

Fructose and glucose content were different on the two site locations but similar for the different seasons within each location. Overall, genotypes planted at Gama-DF had higher fructose and glucose concentrations than those planted at Itabaiana-SE. Sweetpotato genotypes 6, 33 and 50 had the same fructose and glucose concentrations in both site locations. Interestingly, these three genotypes were also the ones that had the lowest concentration of these two monosaccharides. The sweetpotato genotypes having the highest fructose concentrations, clones 8, 66, 75, 79 and Beauregard, had concentrations ranging from 0.8-1.1 g $100g^{-1}$ at Gama-DF. No concentration difference for this same sugar was found at Itabaiana-SE (Table 5). Glucose concentration was highest in clone 79, at 1.4 g $100g^{-1}$.

Sucrose concentration was similar within the two seasons and two locations evaluated, ranging from 3.1 to 5.0 g $100g^{-1}$ among the different clones (Table 5). The average sucrose content for cv. Beauregard in the four experiments performed (3.1g $100g^{-1}$) was very similar to that reported previously (3.4 g $100g^{-1}$) (Yencho *et al.*, 2008). Clones 6, 8, 33, 50 and 75 had the highest sucrose concentrations, while cv. Beauregard and clones 66 and 79 had the lowest sucrose content (Table 5).

Fructose, glucose and sucrose are the predominant sugars in raw fresh sweetpotato roots (Kitahara *et al.*, 2017). The evaluation of the different sweetpotato genotypes demonstrated that clones 6, 8 and 75 had the greatest amount of these free sugars (total sugars) in comparison to the remaining genotypes evaluated. Sucrose was the predominant sugar in the root samples evaluated, representing from 63 to 83% of the total sugar content (Table 6).

Table 4: Means cluster between sites for root dry mater and brix evaluated in sweetpotato genotypes in two different regions

Genotypes	Dry matter (%)		Brix (ºBx)	
	Gama-DF	Itabaiana-SE	Gama-DF	Itabaiana-SE
6	26.7 dA	24.3 bA	13.4 aA	13.0 bA
8	31.5 cA	30.1 aA	13.7 aA	12.0 cB
9	34.3 bA	30.4 aB	10.8 cA	9.8 dB
33	30.5 cA	29.9 aA	13.7 aA	13.8 aA
50	25.4 dA	26.4 bA	12.3 bA	12.0 cA
66	20.7 eA	22.2 bA	8.8 dB	11.0 cA
75	30.0 cA	29.4 aA	13.4 aB	14.5 aA
79	24.1 dA	23.5 bA	12.7 bA	11.3 cB
Beauregard	24.8 dA	23.5 bA	9.9 cA	9.5 dA
Olho Roxo	33.8 bA	29.5 aB	13.7 aA	11.8 cB
Ourinhos	37.8 aA	33.1 aB	13.0 bA	11.1 cB

*Means with different letters lowercase within the column and uppercase letters within lines are significantly different ($p < 0.05$) according Scott-Knott and t tests, respectively. Dry matter data from Gama-DF and Itabaiana-SE is the mean of two independent experiments with four replicates on each trial.

Table 5: Fructose and glucose evaluated in sweetpotato genotypes in two different regions

Genotypes	Fructose g 100g^{-1}		Glucose g 100g^{-1}	
	Gama-DF	Itabaiana-SE	Gama-DF	Itabaiana-SE
6	0.4 bA	0.5 aA	0.6 bA	0.7 aA
8	1.0 aA	0.4 aB	1.2 aA	0.5 aB
33	0.4 bA	0.4 aA	0.5 bA	0.5 aA
50	0.4 bA	0.3 aA	0.6 bA	0.5 aA
66	1.0 aA	0.6 aB	1.3 aA	0.9 aB
75	0.8 aA	0.4 aB	1.2 aA	0.7 aB
79	1.1 aA	0.4 aB	1.4 aA	0.6 aB
Beauregard	1.0 aA	0.7 aB	1.3 aA	0.8 aB

*Means with different lowercase letters within columns and uppercase letters within lines are $p < 0.05$ according Scott-Knott and t tests, respectively.

Table 6: Sucrose and total sugars in sweetpotato genotypes on average of two different regions

Genotypes	Sucrose g 100g^{-1}	Total sugars g 100g^{-1}
6	4.8 a	5.9 a
8	4.2 a	5.7 a
33	4.4 a	5.2 b
50	4.3 a	5.2 b
66	3.3 b	5.2 b
75	5.0 a	6.6 a
79	3.8 b	5.5 b
Beauregard	3.1 b	4.9 b

*Means with different letters within the column are significantly different ($p < 0.05$) according to Scott-Knott test.

Because laboratory sugar analysis is a laborious and expensive process for broad screening of vegetable genotypes, refractometry has been substituted to expedite plant carbohydrate measurements (Feller & Fink, 2007). A previous study on asparagus (*Asparagus officinalis* L.) demonstrated that refractometry was unsuitable for direct measurement of fructose, glucose and sucrose concentrations (Feller & Fink, 2007). However, the same authors observed that refraction readings could be used to establish a regression function that could precisely estimate the content of these sugars.

The content of fructose, glucose and sucrose, which are present in both raw and cooked sweetpotato roots, does not change significantly after cooking (Kitahara *et al.*, 2017). Additionally, the perception of sweetness of these three soluble sugars is differently perceived by the palate (Clemens *et al.*, 2016). Therefore, the identification of genotypes having higher sugar content in comparison to the most commonly planted cultivar in Brazil (Beauregard), is a convenient and useful alternative for the industry and the root fresh market in Brazil.

Sweetpotatoes are easy-to-grow, widely adapted, low-cost crop that has a high potential for root production per unit area, commonly more than 40 tons of commercial roots per hectare (Neela & Fanta, 2019). Therefore, it is an excellent source of low-cost food energy. Furthermore, OFSP cultivars are also an important source of dietary carotenoids. This study found differences in the content of total carotenoids, betacarotene and sugars depending on where the sweetpotatoes are cropped demonstrating the importance of evaluating regionally it advanced clone prior to its commercial release.

The correlation analysis is an important tool to understand the relation among different traits. It was verified that in general, sucrose content was negatively correlated with fructose and glucose, being fructose and glucose correlated with each other (Table 7). This finding is in accordance with previous findings since sucrose is composed of glucose and fructose units. Therefore, it is expected to have genotypes with high content of reducer sugars (glucose and fructose) and others with high contents of sucrose (Adu-Kwarteng *et al.*, 2014).

There was positive correlation among Brix and total carotenoids and sucrose content on samples from both locations. However, this was not observed among Brix and fructose and glucose. Dry matter content was correlated with total carotenoids in both locations, and with beta-carotene in Itabaiana-SE. Dry matter also was correlated with the sucrose content, but negatively with fructose and glucose, in Itabaiana-SE.

This indicates that in this set of genotypes is difficulty to associate high glucose and fructose content and other

Table 7: Correlations among the different quality characteristics

	TC	BC	DM	Sucrose	Fructose	Glucose	TS	Brix
TC	-	0.99*	0.35*	0.46*	0.08	0.16	0.54*	0.41*
BC	1.00*	-	0.33	0.50*	0.05	0.13	0.55*	0.39*
DM	0.58*	0.59*	-	0.55*	-0.21	-0.25	0.33	0.85*
Sucrose	0.15	0.15	0.35*	-	-0.43*	-0.33	0.62*	0.65*
Fructose	-0.10	-0.09	-0.43*	-0.43*	-	0.96*	0.44*	-0.25
Glucose	-0.07	-0.05	-0.43*	-0.43*	0.94*	-	0.52*	-0.25
TS	0.04	0.04	0.10	0.83*	0.06	0.08	-	0.40*
Brix	0.43*	0.43*	0.55*	0.42*	-0.35*	-0.28	0.26	-

TC. total carotenoids, BC. betacarotene, DM. dry matter, TS. total sugars. *Significant according test t at 5%. Above diagonal Gama-DF; Below diagonal Itabaiana-SE.

quality traits such as sucrose, carotenoids, dry matter, and Brix. However, is easier to find genotypes with high sucrose content associated with the other quality traits.

CONCLUSION

The evaluation in different seasons of the year did not affect sweetpotato carotenoid concentrations demonstrating that weather conditions did not directly influence carotenoid formation.

The assessment of nutrient concentrations at Sergipe and Distrito Federal revealed that site location and different soil conditions directly influenced carotenoid, dry matter, fructose and glucose concentrations in the different sweetpotato genotypes evaluated.

The great majority of white fleshed sweetpotato genotypes presented storage roots with higher dry matter content than the orange fleshed genotypes.

ACKNOWLEDGEMENTS, FINANCIAL SUPPORT AND FULL DISCLOSURE

The authors would like to thank the Harvest Plus Program (grant number 2014H6332 -EMB) that financially supported this project and Dr. Mary Shaw for a kind review of the manuscript. The authors do not have any conflict of interests in execution and publishing the manuscript.

REFERENCES

Adu-Kwarteng E, Sakyi-Dawson EO, Ayernor GS, Truong VD, Shih FF & Daigle K (2014) Variability of sugars in staple-type sweet potato (*Ipomoea batatas*) cultivars: the effects of harvest time and storage. International Journal of Food Properties, 17:410-420.

Anvisa (2005) O regulamento técnico sobre a ingestão diária recomendada (idr) de proteína, vitaminas e minerais. Available at: <https://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2005/rdc0269_2022_2009_2005.html>. Accessed on: May 12th, 2022.

Berni P, Chitchumroonchokchai C, Canniatti-Brazaca SG, de Moura FF & Failla ML (2015) Comparison of content and *in vitro* bioaccessibility of provitamin A carotenoids in home cooked and commercially processed orange fleshed sweet potato (*Ipomoea batatas* Lam). Plant Foods for Human Nutritrion, 70:01-08.

Clemens R, Jones J, Kern M, Lee S-Y, Mayhew E, Slavin J & Zivanovic S (2016) Functionality of sugars in foods and health. Comprehensive Reviews in Food Science and Food Safety, 15:433-470.

Cruz CD (2016) Genes Software - extended and integrated with the R, Matlab and Selegen. Acta Scientiarum, 38:547-552.

Cruz CD, Regazzi AJ & Carneiro PCS (2014) Modelos biométricos aplicados ao melhoramento genético. 3ª ed. Viçosa, UFV. 668p.

Feller C & Fink M (2007) Refraction as a measure of soluble carbohydrates in storage roots of asparagus. HortScience, 42:57-60.

Horwitz W & Latimer GW (2010) Official Methods of Analysis of Aoac International. 18º ed. Gaithersburg, AOAC International. 3390p.

Kathabwalika DM, Chilembwe EHC, Mwale VM, Kambewa D & Njoloma JP (2013) Plant growth and yield stability of orange fleshed sweet potato (*Ipomoea batatas*) genotypes in three agro-ecological zones of Malawi. International Research Journal of Agricultural Science and Soil Science, 3:383-392.

Kitahara K, Nakamura Y, Otani M, Hamada T, Nakayachi O & Takahata Y (2017) Carbohydrate components in sweetpotato storage roots: their diversities and genetic improvement. Breeding Science, 67:62-72.

Laurie S (2013) Genotype x environment interaction and yield stability estimate of some sweet potato [*Ipomoea batatas* (L.)Lam] breeding lines in South Africa. Journal of Plant Breeding and Crop Science, 5:182-186.

Low JW, Mwanga ROM, Andrade M, Carey E & Ball A-M (2017) Tackling vitamin A deficiency with biofortified sweetpotato in sub-Saharan Africa. Global Food Security, 14:23-30.

Macrae R (1998) Food science and technology: A series of monographs: HPLC in food analysis. New York, Academic Press. 502p.

Manrique K & Hermann M (2000) Effect of GxE interaction on root yield and betacarotene content of selected sweetpotato (*Ipomoea batatas* (L) Lam.) varieties and breeding clones. Open Access Library Journal, 11:281-288.

Neela S & Fanta SW (2019) Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency. Food Science & Nutrition, 7:1920-1945.

Pacheco S, Peixoto FM, Borguini RG, Nascimento LSM, Bobeda CRR, Santiago MCPA & Godoy RLO (2014) Microscale extraction method for HPLC carotenoid analysis in vegetable matrices. Scientia Agricola, 71:416-419.

Rodriguez-Amaya DB, Kimura M & Amaya-Farfan J (2008) Fontes Brasileiras de Carotenóides - Tabela Brasileira de Composição de Carotenóides em Alimentos. Brasília, MMA. 101p.

Rolston LH, Clark CA, Cannon JM, Randle WM, Riley EG, Wilson

PW & Robbins ML (1987) Beauregard Sweet-Potato. Hortscience, 22:1338-1339.

Santos FN, Duarte LN, Samborski T, Mello AFS, Kringel DH & Severo J (2021) Elaboration of food products with biofortified sweet potatoes: Characterization and sensory acceptability. Revista chilena de nutrición, 48:59-66.

Santos HGD, Jacomine PKT, Anjos LHCD, Oliveira VAD, Lumbreras JF, Coelho MR, Almeida JAD, Araujo Filho JCD, Oliveira JBD & Cunha TJF (2018) Brazilian Soil Classification System. Brasília, Empraba Solos. 356p.

Tiburski JH, Rosenthal A, Deliza R, de Oliveira Godoy RL & Pacheco S (2011) Nutritional properties of yellow mombin (*Spondias mombin* L.) pulp. Food Research International, 44:2326-2331.

Truong VD, Avula RY, Pecota KV & Yencho GC (2018) Sweetpotato production, processing and nutritional quality. In: M Siddiq & MA Uebersax (Eds.) Handbook of vegetables and vegetable processing. New Jersey, John Wiley & Sons Ltd. p.811-838.

Wiseman EM, Bar-El Dadon S & Reifen R (2017) The vicious cycle of vitamin a deficiency: A review. Critical Reviews in Food Science and Nutrition, 57:3703-3714.

Yencho C, Pecota K, Schultheis J, Pesic-VanEsbroeck Z, Holmes G, Little B, Thornton A & Truong VD (2008) 'Covington' Sweetpotato. HortScience 43:1911-1914.