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Physicochemical and biochemical traits of sweet pepper hybrids as a function of harvest times

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ABSTRACT

The current study aims to evaluate in commercial hybrids the influence of harvest period about physicochemical and biochemical characterization of different genotypes at the unripe fruit stages. Therefore, 16 hybrids were assessed within 4 harvest times, making up to 64 treatments. Physicochemical and biochemical characterization of sweet pepper at unripe fruit stages were influenced by harvest times and genotypes. Results indicated a decrease in pigment contents in all hybrids when harvested at 130 days after sowing (DAS). Additionally, Eppo, Magali, Dahra and Anabell decreased in ascorbic acid contents at 175 DAS; while Melina, Anabell, Don Santino, Balico and Lucigno increased in reducing sugar contents at same harvest time.

1. Introduction

Sweet peppers (*Capsicum annuum* L.) belong to the solanaceous family. Among vegetables, they stand out for their greatest commercial value; colours, shapes and flavours diversity; also allowing consumption in both fresh and processed forms, such as compotes, sauces and seasonings (Blank, Souza, & Gomes, 1995; Filgueira, 2008; Kluge et al., 2014).

Several studies has been reporting the importance of consuming fruits and vegetables to reduce the incidence of degenerative diseases, such as cancer, cardiovascular, inflammation, arthritis, immune system, brain dysfunction, diabetes, Alzheimer and some types of cataract (Siqueira & Oetterer, 1997; Lima, Melo, & Lima, 2002). However, all nutraceutical properties present in fruits and vegetables are largely influenced by genotypes, environmental conditions and production system (Melo, 2006). Sweet peppers present high genetic diversity in terms of colours, sizes, shapes and biochemical compositions; besides varying in their antioxidant properties, vitamin and phytochemicals compositions (Lee, Howard, & Villalon, 1995).

Currently, there is a great diversity of sweet peppers in relation to shape, colour or size. In general, they are of high quality with the highest marketprice and greater profitability for producers.

Sweet pepper cultivars have changed consumer market, since they guarantee uniformity in fruits shape, predominantly rectangular; thick pulp and different colours, whose is linked to 'Haute cuisine'. Therefore, sweet peppers enable preparing refined dishes that can be easily found in mainstream restaurants, mainly in large urban centres. Moreover, sweet peppers are sold in a range of colours that vary from cream to almost black, going through yellow, orange, red and purple (Scivittaro et al., 1999).

However, there is a paucity of literature on the nutritional potential of different genotypes of sweet peppers. Researches mostly focus on productive traits, such as weight, number of fruits per plant and yield; but physicochemical and biochemical characterization are of great importance (Rocha, Carmo, Polidoro, Silva, & Fernandes, 2006), such variables may be necessary to improve marketing by adding value due to nutritional benefits.

The market of fresh fruits and vegetables presents high perishability. Among the main deterioration processes, there are pigments degradation, conversion of starch into sugars, firmness reduction, pectin degradation and changes in enzymes activities (Lemos, Rebouças, José, Vila, & Silva, 2007).

There should be an association of productive materials and genotypes characterization to extend shelf life and nutritional quality; however, breeding programs rarely consider that. Corrêa, Gouveia, Tavares, Evangelista, and Cardoso (2015) observed differences in the

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quality of hybrids and lineages of sweet peppers, reporting loss in mass, soluble solids, titratable acidity, pH and reducing sugars.

The current study aims to evaluate the commercial hybrids of sweet pepper and the influence of harvest period about physicochemical and biochemical characterization of different genotypes at the unripe fruit stages.

2. Material and methods

The experiment was conducted at São Manuel Experimental Farm, belonging to the School of Agriculture of Botucatu (FCA/UNESP) at the following coordinates 22°46′S 48°34′W and 740 m above sea level. According to the Köppen climate classification, São Manuel is considered Cwa (humid subtropical climate) with average annual rainfall of 1377 mm and average highs barely exceed 22 °C (Cunha & Martins, 2009). Soil is classified as typic dystrophic Red Latosol (Embrapa, 2006).

Before the experiment, soil samples were collected at a depth of 0–20 cm for chemical analysis: pH = 5.8; organic material = 9 g dm^{-3}; P = 35 mg dm^{-3}; H + Al = 15 mmol dm^{-3}; K = 1.9 mmol dm^{-3}; Ca = 28 mmol dm^{-3}; Mg = 10 mmol dm^{-3}; base sum = 40 mmol dm^{-3}; cation exchange capacity = 55 mmol dm^{-3}; base saturation = 72%. Based on soil analysis, Raij, Andrade, Cantarella, and Quaggio (1997) recommends 40 kg ha^{-1} of nitrogen (N), 320 kg ha^{-1} of phosphorus (P_2O_5), 120 kg ha^{-1} of potassium (K_2O) at planting fertilization; in addition to 40 t $ha^{-1}$of organic compound Provaso®. Among cultural treatments were weeding, sprinkler irrigation and spraying to control pests.

Sowing was made in polypropylene trays of 162 cells with commercial substrate. After 45 days, seedlings were transplanted to field using distances between plants of 0.5 m and between rows of 1.0 m. Topdressing fertilization was performed every 15 days using the 20-0-20 formulated, according to crop recommendations (Raij et al., 1997). Sixteen commercial hybrids (Orangela, Sansão, Margarida, Platero, Eppo, Cida, Beti, Melina, Magali, Dahra, Anabell, Don Santino, Sócrates, Balico, Lucignoand Lussac) were assessed within four harvest times (at 130, 145, 160 and 175 days after sowing) using a randomized block design with four replications and six useful plants per plot.

After harvesting, unripe fruits were washed in running water and separated into groups of three to compose each plot replicates. Afterwards, laboratory analyzes consisted of titratable acidity, soluble solids, pH, reducing sugars, ascorbic acid, instrumental colour, chlorophyll *a*, chlorophyll *b*, anthocyanins and total carotenoids.

Titratable acidity was determined by titrating 5 g of homogenized pulp in 100 ml of distilled water against 0.1 N NaOH, using phenolphthalein, expressed as a percentage of citric acid, as described by Adolfo Lutz Institute (Brazil, 2008). Soluble solids (SS) was determined in electronic refractometer (PR32 ATAGO) by direct reading in °Brix, according to Association of Official Analytical Chemistry (AOAC, 2016). The pH was determined in macerated pulp by direct reading using a potentiometer (Digital DMPH-2), according to Adolfo Lutz Institute (Brazil, 2008).

Reducing sugars contents were determined by Somogyi (1945) and Nelson (1944) method, results are expressed as a percentage. The ascorbic acid content was determined by the MAPA methodology (2005), results are expressed in mg 100 g^{-1} of pulp.

The instrumental colour was determined in three points of each fruit with Konica Minolta® colorimeter (CR-400 chroma-meter, illuminant D65) and readings are expressed in the colour system CIE L∗a∗b∗ (Konica Minolta, 1998). The components used were lightness, chroma and Hue angle. For pigments analysis, it was used the method recommended by Sims and Gamon (2002), in a light protected environment with results expressed in mg 100 g^{-1} of pulp. The absorbance spectrophotometer reading was performed in four wavelengths, 663, 645,537, 470 nm for chlorophyll *a*, chlorophyll *b*, anthocyanins and carotenoids, respectively.

Data were submitted to analysis of variance and averages compared with Tukey test ($p < 0.05$) for postharvest traits in the statistical software SISVAR (Ferreira, 2011).

Table 1
Titratable acidity (% citric acid), pH, and ascorbic acid (100 mg^{-1}g pulp) of different hybrids of sweet pepper at unripe fruit stage. FCA/UNESP. 2015.

Harvesting (days after sowing)	130	145	160	175
Hybrids	pH			
ORANGELA	5.52 bcA	5.48 aA	5.39 aA	5.58 abA
SANSÃO	5.70 abcAB	5.86 aA	5.36 aB	5.76 abAB
MARGARIDA	5.46 bcB	5.90 aA	5.39 aB	5.56 abAB
PLATERO	5.65 abcAB	5.90 aA	5.45 aB	5.86 abAB
EPPO	5.40 cB	5.93 aA	5.34 aB	5.97 aA
CIDA	5.49 bcAB	5.57 aAB	5.25 aB	5.75 abA
BETI	5.51 bcAB	5.93 aA	5.31 aB	5.81 abA
MELINA	5.84 abcA	5.69 aAB	5.36 aB	5.95 aA
MAGALI	5.53 bcAB	5.95 aA	5.35 aB	5.86 abAB
DAHRA	6.03 abA	5.89 aA	5.64 aA	5.97 aA
ANABELL	5.55 bcA	5.70 aA	5.37 aA	5.50 abA
DON SANTINO	6.20 aA	5.74 aB	5.63 aB	5.37 bB
SÓCRATES	5.57 bcA	5.73 aA	5.50 aA	5.57 abA
BALICO	5.88 abcA	5.59 aAB	5.44 aB	5.53 abAB
LUCIGNO	5.66 abcA	5.69 aA	5.35 aA	5.70 abA
LUSSAC	5.66 abcAB	5.87 aA	5.30 aB	5.77 abA
CV (%)	4.12			
Hybrids	Titratable acidity (% citric acid)			
ORANGELA	0.102 bB	0.182 abA	0.110 aB	0.190 abA
SANSÃO	0.085 bB	0.160 bA	0.117 aB	0.170 bA
MARGARIDA	0.120 bB	0.172 abA	0.102 aB	0.197 abA
PLATERO	0.105 bB	0.182 abA	0.105 aB	0.202 abA
EPPO	0.107 bB	0.172 abA	0.115 aB	0.167 bA
CIDA	0.107bB	0.187 abA	0.117 aB	0.180 abA
BETI	0.092 bB	0.210 abA	0.110 aB	0.175 bA
MELINA	0.110 bB	0.215 abA	0.117 aB	0.197 abA
MAGALI	0.107 bB	0.227 aA	0.115 aB	0.192 abA
DAHRA	0.110 bB	0.205 abA	0.107 aB	0.200 abA
ANABELL	0.132 bB	0.195 abA	0.117 aB	0.232 aA
DON SANTINO	0.090 bC	0.162 bB	0.117 aC	0.220 abA
SÓCRATES	0.220 aA	0.190 abA	0.112 aB	0.220 abA
BALICO	0.107 bB	0.210 abA	0.122 aB	0.202 abA
LUCIGNO	0.120 bB	0.177 abA	0.117 aB	0.207 abA
LUSSAC	0.095 bB	0.195 abA	0.112 aB	0.190 abA
CV (%)	14.66			
Hybrids	Ascorbic acid (100 m g^{-1} pulp)			
ORANGELA	31.66 abcA	30.48 abA	26.14 aA	19.77 abA
SANSÃO	37.38 abA	29.97 abA	30.61 aA	28.70 abA
MARGARIDA	33.16 abcA	23.98 abAB	19.64 aB	29.97 abAB
PLATERO	31.66 abcA	21.68 abA	23.34 aA	23.98 abA
EPPO	35.72 abcA	30.61 abAB	23.59 aAB	21.04 abB
CIDA	32.90 abcA	23.58 abA	24.49 aA	25.51 abA
BETI	27.04 abcA	15.30 bA	19.90 aA	19.13 bA
MELINA	23.21 bcA	26.78 abA	25.22 aA	23.59 abA
MAGALI	41.58 aA	18.49 abB	27.42 aB	20.66 abB
DAHRA	36.99 abA	25.25 abAB	22.70 aB	17.85 bB
ANABELL	38.26 abA	17.22 bB	19.77 aB	24.23 abB
DON SANTINO	28.44 abcA	34.82 aA	27.80 aA	36.99 aA
SÓCRATES	38.77 abA	29.97 abAB	22.32 aB	31.88 abAB
BALICO	19.13 cAB	25.89 abAB	14.67 aB	28.06 abA
LUCIGNO	28.95 abcA	26.78 abA	20.41 aA	23.21 abA
LUSSAC	23.59 bcA	13.77 bA	23.34 aA	20.66 abA
CV (%)	26.94			

Means followed by same, lowercase letters in the columns and rows in the case, not significantly different by Tukey test ($p < 0.05$). CV (%): coefficient of variation.

3. Results and discussion

Among postharvest traits (i.e. pH, titratable acidity and ascorbic acid), there was a significant interaction between hybrids and harvest times (Table 1). At 130 days after sowing (DAS), higher averages of pH were observed in Sansão, Platero, Melina, Dahra, Don Santino, Balico,