Journal of Food Composition and Analysis 57 (2017) 73–79

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca

Original Research Article

Carotenoid and total vitamin C content of peppers from selected Brazilian cultivars

Tânia da Silveira Agostini-Costa[a,*], Ismael da Silva Gomes[a], Luis Alberto Martins Palhares de Melo[a], Francisco Jose Becker Reifschneider[b], Cláudia Silva da Costa Ribeiro[b]

[a] Embrapa Recursos Genéticos e Biotecnologia, Parque Estação Biológica, PqEB, W5 norte, 70770-917, Brasília, DF, Brazil
[b] Embrapa Hortaliças, Rodovia Brasília/Anápolis BR 060 km 09, 70359-970, Gama, DF, Brazil

ARTICLE INFO

Article history:
Received 17 May 2016
Received in revised form 1 December 2016
Accepted 20 December 2016
Available online 21 December 2016

Chemical compounds studied in this article:
Capsanthin (PubChem CID: 5281228)
Capsorubin (PubChem CID: 5281229)
Violaxanthin (PubChem CID: 449438)
Antheraxanthin (PubChem CID: 5281223)
Zeaxanthin (PubChem CID: 5280889)
Lutein (PubChem CID: 5281243)
β-Cryptoxanthin (PubChem CID: 5281235)
α-Carotene (PubChem CID: 4369188)
β-Carotene (PubChem CID: 5280489)
Ascorbic acid (PubChem CID: 54670067)

Keywords:
Capsicum annuum
C. chinense
Solanaceae
Capsanthin
Zeaxanthin
Provitamin A
Ascorbic acid
Food analysis
Food composition
HPLC

ABSTRACT

Carotenoid and ascorbic acid content was determined in peppers of two red cultivars and three yellow lineages of “Jalapeño” (*Capsicum annuum* L.) plus a “sweet red biquinho” and a “red bode” cultivar (*C. chinense* Jacquin) from the Brazilian Breeding Program. Capsanthin (68 ± 3 to 177 ± 2 μg/g) was found to be the main carotenoid in the red peppers, and violaxanthin (34 ± 3 to 100 ± 17 μg/g) was the main carotenoid in the yellow jalapeño peppers. Red jalapeño peppers grown in the field (in summer) showed higher zeaxanthin (29 ± 0 and 31 ± 2 μg/g), β-cryptoxanthin (11 ± 1 and 7 ± 0 μg/g), provitamin A (161 ± 2 and 81 ± 2 μg/g) and ascorbic acid (132 ± 2 and 129 ± 2 μg/g) than peppers grown in the greenhouse. Peppers of one yellow jalapeño lineage (*C. annuum*) and of the red “bode” cultivar (*C. chinense*) also stood out for their very high levels of zeaxanthin (36 ± 6 and 53 ± 7 μg/g), besides nutritional compounds, provitamin A (222 ± 17 and 299 ± 32 retinol activity equivalents/100 g) and vitamin C (152 ± 5 and 123 ± 1 mg/100 g). These results indicate that the selected peppers presented compounds that are beneficial for human health and that they could be used in the Brazilian pepper breeding programs to develop new commercial hybrids.

1. Introduction

Species of *Capsicum*, from the Solanaceae family, are widely produced and consumed around the world (Giuffrida et al., 2013; Ornelas-Paz et al., 2013), and Brazil is an important center of diversity for this genus. *Capsicum annuum* L. is the species most cultivated in Brazil, and *C. chinense* Jacquin is the Brazilian species with the highest diversity in the Amazon Basin (Ribeiro and Reifschneider, 2008); both species are inter-crossable and can produce fertile and heterogeneous hybrids (Wahyuni et al., 2011). Jalapeño is one of the most popular varieties (Alvarez-Parrila et al., 2011) of *C. annuum*, while “Bode” and “Biquinho” are highly flavored varieties of *C. chinense* (Garruti et al., 2013) that are much sought after by Brazilian farmers (Ribeiro and Reifschneider, 2008).

Peppers are a rich source of phytochemicals such as vitamins (Wahyuni et al., 2011; Zhuang et al., 2012), capsaicinoids (Aguiar et al., 2016), carotenoids (Giuffrida et al., 2013; Gómez-García and

Abbreviations: cv, cultivar; HPLC, high performance liquid chromatography; TCEP-HCl, tris 2-carboxyethyl-phosphine hydrochloride.

* Corresponding author.
E-mail address: tania.costa@embrapa.br (T. da Silveira Agostini-Costa).

http://dx.doi.org/10.1016/j.jfca.2016.12.020
0889-1575/

Ochoa-Alejo, 2013; Ha et al., 2007; Rodríguez-Burruezo et al., 2010; Wall et al., 2001) and polyphenols (Wahyuni et al., 2011; Zhuang et al., 2012). Carotenoids are lipophilic C40 isoprenoids with polyene chains and different end groups (β, ε, κ) (Britton, 1995a). The presence of numerous conjugated double bonds and cyclic end groups is crucial for their roles in light harvesting in photosynthetic organisms and (photo) protection in all living organisms (Britton et al., 1995; Niranjana et al., 2015). Carotenoids are classified into oxygen-free carotenes, such as α-carotene and β-carotene and oxygen-containing xanthophylls, such as β-cryptoxanthin, zeaxanthin, violaxanthin and capsanthin (Britton, 1995a). They are the main determinants of pepper color in several species of the *Capsicum* genus (Ha et al., 2007), and the red-colored fraction contains two distinctive κ-xanthophylls known as capsanthin and capsorubin, which are pigments exclusive to this genus (Hornero-Méndez et al., 2000).

Some carotenoids show provitamin A activity (IOM, 2001); some such as capsanthin, β-carotene, zeaxanthin and lutein have been confirmed as antioxidants (Müller et al., 2011) with health benefits in the prevention or alleviation of various diseases (Bian et al., 2012; Dhingra and Bansal 2014; Niranjana et al., 2015). Ripe red peppers present a higher antioxidant capacity than green fruits (Cervantes-Paz et al., 2012; Kim et al., 2011). Ascorbic acid is the main vitamin C compound and is another functional and nutritional constituent of pepper fruit (Teodoro et al., 2013; Topuz and Ozdemir 2007); it is well known as an antioxidant and bioactive compound, particularly in ripe peppers (Kim et al., 2011; Topuz and Ozdemir 2007).

Jalapeño peppers have shown antioxidant properties (Alvarez-Parrila et al., 2011) and demonstrated effective action against food lipid and human LDL cholesterol oxidation (Alvarez-Parrilla et al., 2012) due to several bioactive compounds. The influence of genetic differences (Wall et al., 2001; Zhuang et al., 2012) and of environmental conditions (Ornelas-Paz et al., 2013) can influence the content of secondary metabolites of peppers and may have implications for their biological effects (Alvarez-Parrilla et al., 2012). The objective in this study was to determine the content of carotenoids, provitamin A and vitamin C in two red cultivars (BRS Garça and BRS Sarakura) and three yellow lineages (CNPH 25.313; 25.324 and 25.296) of Jalapeño peppers (*C. annuum* L.), and in two red and flavored cultivars (BRS Moema and BRS Seriema) of *C. chinense* Jacquin grown in Brazil's Central region. Additionally, some differences observed due to their growing environment were also evaluated. The results may help to know more about the nutritional and health potential of some important Brazilian pepper cultivars, associated with their growing environment. They may also help Brazilian pepper-breeding programs to develop new commercial hybrids at produce fruits enriched with health-related compounds.

2. Material and methods

2.1. Plant materials

Peppers were grown at the experimental area of Embrapa Vegetable Crops, Gama, DF, Brazil (latitude: 15.8° W; longitude: 47.9° S; altitude: 990 m) according to Ribeiro et al. (Ribeiro et al., 2008) and harvested in the summer and spring of 2014 (total rainfall: 507 mm in the summer and 58 mm in the spring). Climatic conditions as described by the National Institute of Meteorology (Brasil, 2014) are represented in Fig. 1.Two red cultivars (BRS Sarakura and Garça) and three yellow lineages (CNPH 25.313, 25.324 and 25.296) were of Jalapeño peppers (*C. annuum* L.); another two red cultivars (BRS Moema – "sweet biquinho pepper" and BRS Seriema – "bode pepper") were of *C. chinense* Jacquin. For red Jalapeño pepper, one sample (about 30 fruits) was taken from each cultivar grown in the field. Another sample of 30 fruits was taken from plants grown in the greenhouse. The latter regime aimed to protect the samples from high incidences of summer rain and sunlight, but the environmental conditions, such as temperature, luminosity and humidity, were not optimized. Of the greenhouse samples, five plants per cultivar were harvested in the summer (February 2014); from each field-grown cultivar, ten plants were harvested in the spring (October 2014), as shown in Table 1. One sample of each lineage of yellow Jalapeño pepper was harvested from the field in the summer (CNPH 25.313 and 25.296), and another sample was taken in the spring (CNPH 25.313 and 25.324). One sample of each cultivar, BRS Moema and BRS Seriema, of *C. chinense* was harvested from the field in the spring. In the greenhouse, red peppers were all harvested at the same time but at three successive maturity stages based on their color (green, partially purple and fully red), aiming to make ascorbic acid valuations. However, for carotenoid analysis, only fully red peppers were used. Red and yellow fruits from the field were always fully ripe, but not overripe.

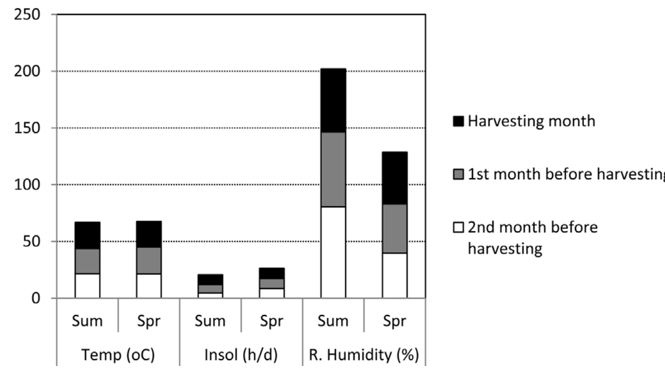

Fig. 1. Climatic conditions (Temp: temperature; Insol: insolation and R. Humidity: relative humidity) in summer 2014 (Sum) and spring (Spr) in Brasília, DF (Brasil, 2014).

In the Laboratory, the fruits were carefully selected to ensure that they were free of defects, totaling about 20 fruits per sample. These fruits were washed, dried with paper towels, frozen in liquid nitrogen, wrapped in plastic bags and stored at −20 °C until the time of extraction.

2.2. Carotenoid extraction

Three analytical repetitions were conducted for each sample. Procedures were carried out according to Minguez-Mosquera and Hornero-Méndez (1993) with adaptations. Carotenoids were extracted using addition of antioxidant (BHT 0.1% Sigma-Aldrich, Steinheim, Germany), protection from light and exclusion of oxygen at air-conditioned room temperature (21 °C). Peppers were devoid of seeds and cut into small pieces. The carotenoids from 3 g of homogenized peppers were extracted in a Polytron homogenizer (Kinematica, Lucerne, Switzerland) for 2 min at 20,000 rpm, using 2 g of celite and 40–50 mL of cold acetone (4 °C), four to five times, until there was a complete lack of color in the residue. The extract of free carotenoids was vacuum filtered, and the pigments were carefully transferred from the acetone to 100 mL of ethylic ether (Riedel-de Haen, Seelze, Germany). The organic phase was dried over anhydrous sodium sulfate and saponified under nitrogen atmosphere using an equal volume of 20% KOH in methanol (J.T. Baker, Phillipsburg, NJ, USA) for 1 h at room temperature. Saponified extract was transferred to a separatory funnel and carefully washed with distilled water, until it reached a pH near to neutral, using alcoholic phenolphthalein. The extract was dried over anhydrous sodium sulfate and vacuum