Food Chemistry 133 (2012) 1131–1137

Contents lists available at SciVerse ScienceDirect

Food Chemistry

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

Carotenoid concentrations of native Andean potatoes as affected by cooking

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ARTICLE INFO

Article history:
Available online 5 September 2011

Keywords:
Potato
Carotenoids
Nutrition
Cooking
Boiling
Andean
Native

ABSTRACT

The effect of boiling on the concentrations of total and individual carotenoids was determined by spectrophotometry and HPLC, in a group of native Andean potato accessions with diverse intensities of yellow flesh colours. Changes in concentrations due to boiling varied significantly among accessions. Boiling significantly reduced the violaxanthin and antheraxanthin concentration of all the accessions. However, the lutein and zeaxanthin concentrations of boiled tubers were not affected or were higher than the concentrations in raw tubers. The intermediate yellow fleshed accession 701862 showed the highest lutein concentration (above 200 μg/100 g, FW) and the deep yellow fleshed accession 704218 showed the highest concentration of zeaxanthin (above 1000 μg/100 g, FW) in raw and boiled tubers. Boiled potatoes of deep yellow fleshed varieties are a significant source of zeaxanthin (above 500 μg per 100 g fresh weight basis).

1. Introduction

Carotenoids are isoprenoid molecules that are widespread in nature and are typically seen as pigments in fruits, flowers, birds and crustacea. Carotenoids have a broad range of functions, especially in relation to human health and their role as biological antioxidants (Fraser and Bramley, 2004). Besides the well known role of β-carotene as a provitamin A carotenoid and of lutein and zeaxanthin in the prevention of cataract and age related macular degeneration (Landrum and Bone, 2001; Seddon, Ajan & Sperduto, 1994), there are some studies that claim that the antioxidant activities of carotenoids are a key factor in reducing the incidence of many diseases including cardiovascular diseases and cancer (Belanger and Johns, 2008; Kospell and Kospell, 2006).

Several studies have characterised the carotenoid concentration of raw potato tubers reporting violaxanthin and lutein or lutein 5–6 epoxide and lutein as the predominant carotenoids with zeaxanthin present at very low levels (Iwansik, Tevini, Stute & Hilbert, 1983; Lu, Haynes, Wiley & Clevidence, 2001). A more recent study reported that significant and predominant amounts of zeaxanthin and antheraxanthin are found in deep yellow fleshed potatoes while the carotenoid profile of yellow potatoes is composed of violaxanthin, antheraxanthin, lutein and zeaxanthin and that of cream fleshed potatoes of violaxanthin, lutein and β-carotene (Burgos et al., 2009).

Carotenoids are understood to be prone to degradation during food processing. For example, the epoxide carotenoids of mango (Gody and Rodriguez-Amaya, 1987) and white-fleshed sweetpotato (Almeida & Panteado, 1988) are very sensitive to most food preparation conditions. In other studies in tomato and several green vegetables, it has been shown that while epoxycarotenoids were somewhat sensitive, lutein and hydrocarbon carotenoids such as β-carotene survived heat treatment (Khachick, et al., 1992).

The effect of cooking on stability of potato carotenoids has hardly been touched. A study that evaluated the effect of cooking on carotenoid concentration of three potato varieties detected only lutein in the samples and reported that lutein concentration was not affected by cooking (Blessington, Nzaramba, Scheuring, Hale, Reddivari & Miller, 2010). A more recent study, that analysed the carotenoid concentration of raw and boiled tubers of four potato varieties with violaxanthin and lutein as the main carotenoid and zeaxanthin present in very low concentration, reported that heat processing transformed all-trans carotenoids to 9-cis and 13-cis isomeric forms or degraded them (Burmesteir, Bondiek, Apel, Kuhne, Hillebrand & Fleishman, 2011).

The present study aims at evaluating the effects of boiling on the carotenoid concentrations of native Andean potato accessions with different intensities of yellow flesh colour. Based on previous research which indicated that carotenoid profiles and concentrations in potato are correlated with the intensity of yellow flesh colour (Burgos et al., 2009), we selected light yellow, intermediate yellow and deep yellow fleshed accessions to determine the effect of boiling

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doi:10.1016/j.foodchem.2011.09.002

on total and individual carotenoid concentrations. Zeaxanthin and antheraxanthin were the predominant carotenoids in the deep yellow fleshed varieties used in this study.

2. Materials and methods

2.1. Plant material

Seven native Andean potato accessions with different intensities of yellow flesh colour were used to evaluate the effect of cooking on the carotenoid concentration. Of the seven cultivars two were light yellow fleshed: 705821 (*Solanum phureja*), 705172 (*S. phureja*), two were intermediate yellow fleshed: 704393 (*Solanum goniocalix*), 701862 (*S. goniocalix*) and three were deep yellow fleshed: 702472 (*S. goniocalix*), 705799 (*S. phureja*) and 704218 (*S. phureja*). Four of the accessions were grown in La Victoria, Junin, Perú between December and May 2009 and the other three were grown in Comas, Junin, Perú between October 2009 and February 2010.

Thirty unblemished medium sized tubers of each of the 12 accessions were collected at random taking tubers from different plants and plots and brought directly to the laboratory for sampling and analysis within the next 3 weeks.

2.2. Sample preparation

2.2.1. Raw tubers

Three samples of each accession of five tubers each were prepared for analysis in the raw state. Tubers were washed thoroughly with tap water (to remove soil residue), rinsed with deionized, distilled water and patted dry with paper towels. The unpeeled tubers were cut into small pieces, homogenised in a food processor and the homogenised sample was analysed immediately.

2.2.2. Boiled tubers

For each accession, three samples of five tubers each were prepared for analysis in the cooked state. Unpeeled tubers were placed in stainless steel pots and covered with water. Two tubers more were included in the pots for control purposes. Tubers were cooked over uniform temperature and considered cooked when a stainless steel probe could penetrate the control tubers easily. Each accession required a different time of cooking ranging between 23 and 34 min. Cooked tubers were then prepared as detailed above for raw tubers.

2.2.3. Carotenoid analysis

Carotenoid analysis was carried out according to the method described by Burgos et al., 2009 which was an adaptation of a method for carotenoid maize analysis developed by Kimura, Kobori, Rodriguez-Amaya, & Nestel, 2007. Total and individual carotenoids were expressed as μg per 100 g fresh weight (FW) and converted to μg per 100 g dry weight (DW) using the corresponding dry matter percentage.

2.3. Statistical analysis

The effects of boiling on the total carotenoid, violaxanthin, lutein, β-carotene concentration were analysed by ANOVA under a randomized complete block design with three field replications. Three factors were considered: year as random factor and accession and treatment (raw and boiled) as fixed factor. The accession was nested in the year. Means were compared by simple effects. In the case of antheraxanthin and zeaxanthin that presented non parametric data the Friedman test was performed for each accession.

All statistical tests were performed using SAS/STAT (version 9.1) software.17 (SAS, 2008) and R (De Mendiburu, 2010).

3. Results and discussion

3.1. Effect of boiling on total and individual carotenoid concentrations

Fig. 1a–f shows typical chromatograms of raw and boiled light yellow, intermediate yellow and deep yellow fleshed accessions. The peaks of violaxanthin and antheraxanthin, that were prominent

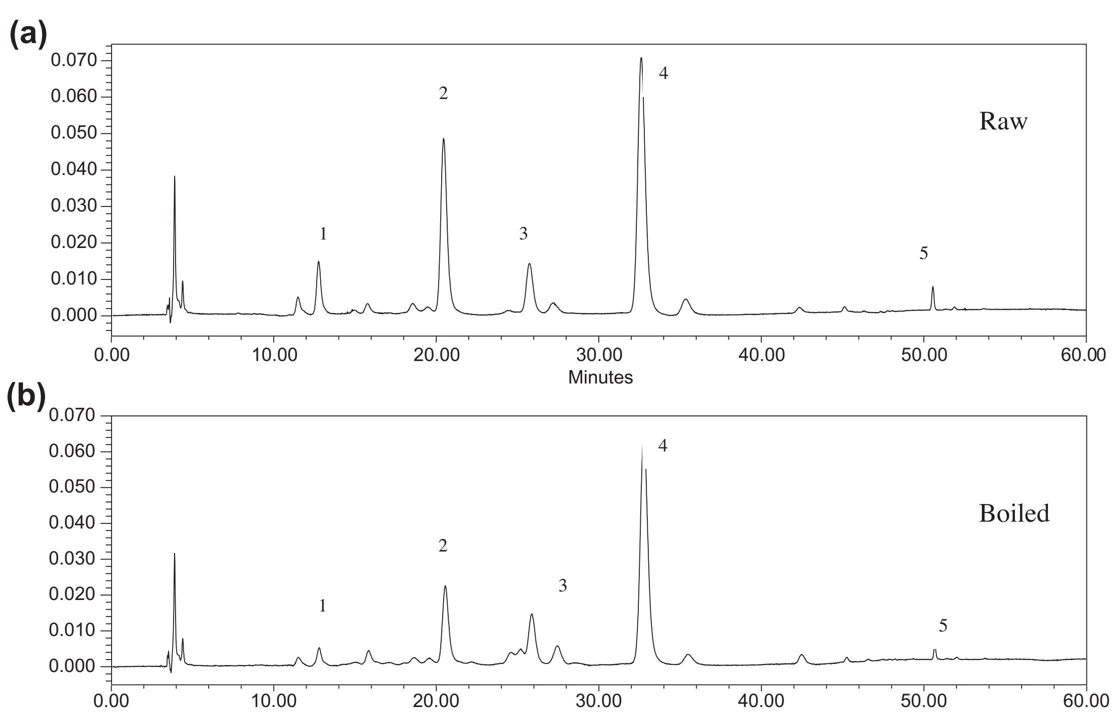

Fig. 1. Typical chromatograms in raw and boiled potatoes of deep yellow fleshed accession (a and b); intermediate yellow fleshed accession (c and d) and light yellow fleshed accession (e and f). (1) violaxanthin, (2) antheraxanthin, (3) lutein, (4) zeaxanthin and (5) β-carotene.