Anteroxanthin Concentration during Refrigerated Storage in Orange Juice Treated by PEF

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Abstract: Pulsed Electric Field (PEF) processing inactivates microorganisms without significant adverse effects on flavor and nutrients. In this work was studied the transformations of antheraxanthin and mutatoxanthin when natural orange juice is treated by pasteurisation (90°C, 20 s) or PEF (30 kV/cm, 100 µs), and also its evolution during seven weeks of storage in refrigeration at two different temperatures (2°C and 10°C). The results showed that antheraxanthin concentration decreased during the storage. The decrease was greater in the untreated, pasteurised and PEF-treated orange juices stored at 10°C and this carotenoid was not detected from the 6th week onwards. The same result was observed in the PEF-treated juice stored at 2°C. However, in the untreated and pasteurised juices stored at 2°C, this carotenoid was detected throughout the storage period, although its concentration decreased. Mutatoxanthin was detected in the 6th week of storage, appearing in the cases in which antheraxanthin disappeared. This was not observed in the untreated or pasteurised orange juices stored at 2°C.

Keywords: antheraxanthin; mutatoxanthin; pulsed electric field; pasteurisation; orange juice; storage

INTRODUCTION

The citrus fruits and their products in general are a complex source of carotenoid pigments, with the largest number of them reported for any fruit (Gross 1987). The importance of carotenoids is based on their two most important properties, their antioxidant capacity and their vitamin A activity. Also, fruit juice colour is principally attributed to various carotenoid compounds, including antheraxanthin and mutatoxanthin.

The main problems associated with carotenoids come from the instability of these pigments, because they are highly unsaturated molecules and are subject to isomerisation. During processing and storage desirable constituents such as nutrients, color, flavor, and texture are destroyed. Although these products must conform to strict guidelines which prevent unnatural changes in the juice, concern about diet and nutrition has led consumers to seek a more natural product (Lee & Coates 2003).

Consumers desire high quality foods that are nutritious, with freshly prepared flavour, texture and colour, with minimal or no chemical preservatives, and above all safe (Bull *et al*. 2004), consequently, the citrus industry has been exploring innovative methods with minimal heat treatment to increase markets by improving nutritional and flavor qualities. Pulsed Electric Field (PEF) processing has the potential to pasteurise various foods non-thermally. The electric field affects the cell membranes (Barsotti & Cheftel 1999), and may cause irreversible membrane breakage, alteration in transport of ions, and changes in enzyme structure (Calderón-Miranda *et al*. 1999), for what inactivates microorganisms without significant adverse effects on flavor and nutrients (Cortés *et al*. 2005, 2006, 2008; Torregrosa *et al*. 2005, 2006). The aim of this work is to study the transformations of antheraxanthin and mutatoxanthin when natural orange juice is treated by means of pasteurisation (90°C, 20 s) or PEF (30 kV/cm, 100 µs), and also its evolution during seven weeks of storage in refrigeration at two different temperatures (2°C and 10°C).

MATERIAL AND METHODS

Samples. Oranges (*Citrus sinensis* L., Navel variety) were purchased in a supermarket in Valencia (Spain). Juice was obtained by squeezing (FMC juice extractor, 2 mm perforated plate) and passed through a filter (pore diameter = 0.23 mm). It was divided into three aliquots: one to be treated by heat, one by PEF and one that was not treated and that was used to ascertain the value of each of the parameters in the fresh juice. Each of the treatments was applied in duplicate.

PEF treatment system. Sample treatments were carried out in a continuous PEF treatment system designed by the University of Ohio. The system consisted of four treatment chambers with a diameter of 0.23 cm and an electrode gap of 0.293 cm connected in series and two cooling coils connected before and after each pair of chambers, immersed in a refrigerated bath in order to keep the temperature within the designated range. The temperature, wave form, voltage and intensity in the treatment chambers were fed into a digital oscilloscope (Tektronix TDS 210, Tektronix, OR U.S.A.). Flow was set at 60 ml/min and controlled by a flow pump (Cole-Parmer 75210-25, Cole-Parmer Instruments, IL). Treatment time was 100 µs and the electric field was set at 30 kV/cm. Samples were collected after treatment.

Thermal treatment. To treat the samples an Armfield FT74P unit with a plate exchanger was used. Juice was impulsed by a pump to the heat exchanger where the treatment conditions (90°C, 20 s) were reached. After treatment, the juice was cooled (Armfield FT61) and it was packed and stored.

Storage conditions. The juice was packaged in Elopack packages (pure-pack®), and they were stored in refrigeration and darkness at 2°C and 10°C (± 2°C) with controlled humidity. Samples were analysed in duplicate immediately after processing, then after 1, 2, 3, 4, 6 and 7 weeks of storage.

Chromatographic determination of carotenes. Carotenoid pigments were extracted, saponified and analysed by chromatography, according to a procedure described by Cortés *et al.* (2004).

RESULTS AND DISCUSSION

The concentration of the antheraxanthin obtained after applying the pasteurisation and PEF treatments to the untreated orange juice is 137.73 ± 4.26, 140.91 ± 8.96 and 161.93 ± 10.14 µg/100 g,

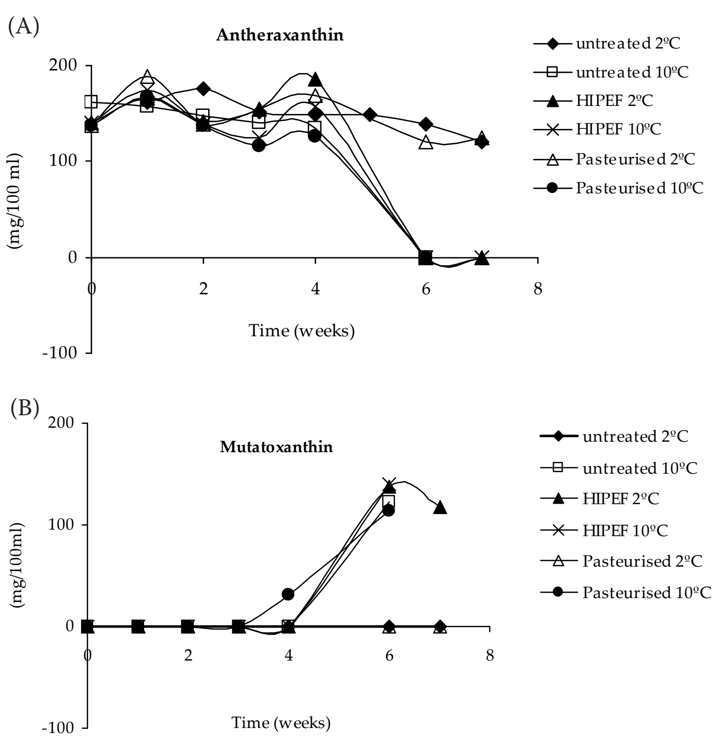

Figure 1. Concentration (µg/100 g) of Antheraxanthin (A) and Mutatoxanthin (B) during storage time in untreated, HIPEF-treated, and pasteurised orange juice stored at 2°C and 10°C

respectively. The study of storage at different temperatures (2 and 10°C) of the untreated orange juice, juice treated with PEF, and pasteurised juice showed that antheraxanthin concentration decreased during this period (see Figure 1A). The decrease was greater in the untreated, pasteurised, and PEF-treated orange juices stored at 10°C, and this carotenoid was not detected from the 6^{th} week onwards. The same result was observed in the PEF-treated juice stored at 2°C. However, in the untreated and pasteurised juices stored at 2°C, this carotenoid was detected throughout the storage period, although its concentration decreased. Another carotenoid, mutatoxanthin, was detected in the 6^{th} week of storage, appearing in the cases in which antheraxanthin disappeared (Figure 1B). This was not observed in the untreated or pasteurised orange juices stored at 2°C, in which antheraxanthin continued to be detected. Carotenoid 5,6-epoxides may be transformed to carotenoid 5,8-epoxides under acidic conditions, so antheraxanthin can be converted into the furanoid structure mutatoxanthin. In previous works Cortés *et al*. (2005) obtained that antheraxanthin concentration in orange-carrot juice decreased during storage at –40°C time and mutatoxanthin under went modifications with storage.

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