The Effects of Non-thermal Processing on Carotenoids in Orange Juice

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Abstract: New non-thermal technologies are emerging, such as pulsed electric fields (PEF) and high hydrostatic pressure (HHP), in order to provide a response to the need for greater nutritional and sensory quality in some manufactured foods in which the characteristics of freshness are especially affected by thermal treatments. The effect of non-thermal processing (PEF, 30 kV/cm, 100 μs and HHP, 4000 bars, 5 min) and pasteurisation (90°C, 20 s) on carotenoids of orange juice was studied. The total carotenoid concentration in the pasteurised juice (1195.4 ± 31.6 μg/100 ml) decreased significantly in comparison with the fresh juice (1367.2 ± 64.7 μg/100 ml), and the decrease was less in the juice treated by PEF (1275.2 ± 56.3 μg/100 ml). The decrease in the juice treated by HHP (1309.2 ± 46.7 μg/100 ml) was no significant in the conditions selected. Only the differences between the untreated orange juice and the pasteurised orange juice were significant. Thus, in refrigerated orange juice, the concentration of carotenoids is affected less by non-thermal treatments (PEF and HHP) than by conventional thermal treatments.

Keywords: carotenoids; pulsed electric field; high hydrostatic pressure; pasteurisation; orange juice

INTRODUCTION

The abundance of fresh drinks based on fruit juices, especially citrus juices, and minimally processed products allow consumers to ingest a wide variety of antioxidants in the diet orange juice is an important source of carotenoids and ascorbic acid, a nutrient that, apart from its vitamin action, is valuable for its antioxidant effect, stimulation of the immune system and other health benefits that are being actively investigated and reported (Miquel *et al*. 2006; Lako *et al*. 2007). During heat treatment, in addition to inactivation of microorganisms, varying percentages of desirable constituents such as nutrients, colour, aroma and texture are destroyed (Alwazeer *et al*. 2002; Blasco *et al*. 2004). Recent studies on the effect that heat has on the quality of various kinds of fruit and vegetables, including orange juice, have indicated a relative loss of total vitamin A content resulting from the loss of certain carotenes present in orange juice (Lee & Coates 2003; Cortés *et al*. 2006). Pulsed electric fields (PEF) and high hydrostatic pressure (HHP) are emerging technologies in the field of food preservation, have the potential to pasteurise various foods non-thermally, and it has been verified that these new technologies guarantee the safety (microorganisms) and stability (enzymes) of juices, with less quality loss in the final product.

The aim of this work, was studied the effect of non-thermal processing (PEF and HHP) and pasteurisation on carotenoids of orange juice and their evolution during storage of orange juice treated by pasteurisation, PEF and HHP.

MATERIAL AND METHODS

Samples. Oranges (*Citrus sinensis* L., Navel variety) were purchased in a supermarket in Valencia (Spain). Juice was obtained by squeesing (FMC juice extractor, 2 mm perforated plate) and passed through a filter (pore diameter = 0.23 mm). It was divided into four aliquots: one to be treated by heat, one by PEF, one by HHP 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, U.S.A.). Flow was set at 60 ml/min and controlled by a flow pump (Cole-Parmer 75210-25, Cole-Parmer Instruments, USA). Treatment time was 100 μs and the electric field was set at 30 kV/cm. Samples were collected after treatment.

HHP treatment. Orange juice was placed in a 50-ml PE-LD flask and treated at 4000 bars for 5 min in an EPSI NV high pressure unit (Belgium). After the treatment the samples were cooled quickly and then analysed.

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 4 ± 2°C and 10 ± 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 carotenoids. Carotenoid pigments were extracted, saponified and analysed by chromatography, according to a procedure described by Cortés *et al*. (2004).

RESULTS AND DISCUSSION

The total carotenoid concentration in the pasteurised juice (1195.4 ± 31.6 μg/100 ml) decreased significantly in comparison with the fresh juice (1367.2 ± 64.7 μg/100 ml), and the decrease was less in the juice treated by PEF (1275.2 ± 56.3 μg/100 ml). The decrease in the juice treated by HHP (1309.2 ± 46.7 μg/100 ml) was no significant in the conditions selected. This agrees with the results obtained by Lee and Coates (2003) for pasteurised orange juice, in which total carotenoid content loss was significant ($P < 0.05$) after thermal pasteurisation at 90°C for 30 seconds. Thus, in refrigerated orange juice, the concentration of carotenoids is affected less by non-thermal treatment (PEF and HHP) than by conventional thermal treatments (Figure 1) and observed that at 4°C the carotenoides concentration in the pasteurised juice descends significantly from the third week of storage, while in the juices treated by PEF and HHP the decrease occurs at fourth week. On the other hand, the juice became spoilage from the sixth week of storage. Also at 10°C, there was a significant descent of the concentration in the juice pasteurised from the second week and from the fourth week of storage in the juice treated by PEF and HHP. Sánchez-Moreno *et al*. (2005) also obtained results similar to the ones described in the present study. The results obtained indicate that with the emerging technologies studied (PEF and HHP) it is possible to obtain orange juice with a high nutritional value and a content of bioactive

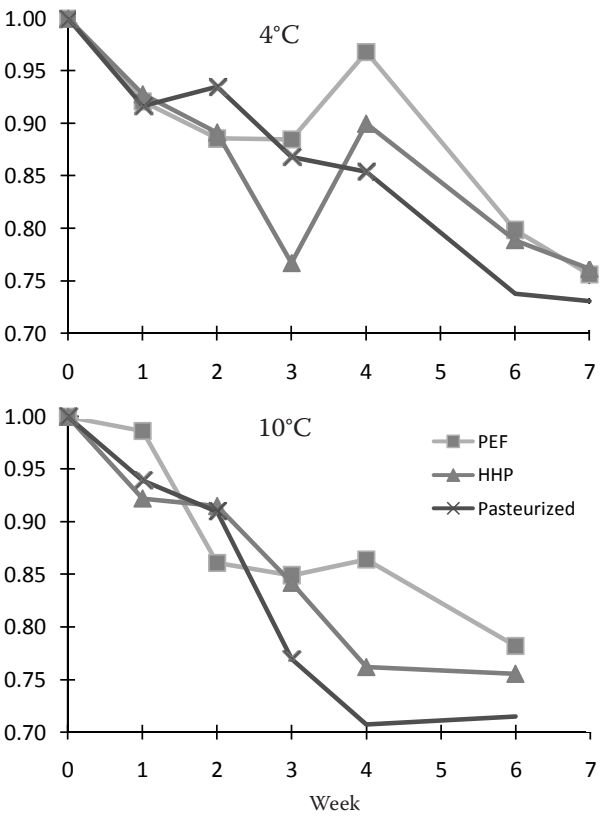

Figure 1. Carotenoids (C/C_0) in PEF, HHP and pasteurised orange juice, during refrigerated storage (4 and 10°C)

compounds similar to that of fresh juice. In comparison with conventional pasteurisation, PEF and HHP treatments led to higher carotenoid content in orange juice immediately after processing, as well as during storage at 4 ± 2 and 10 ± 2°C.

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