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Influence of cold storage and blanching on the carotenoid content of *Kintoki* carrots

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Abstract

A high consumption of lycopene is associated with a decreased risk of cardiovascular diseases and cancer. A lycopene containing carrot variety, *Kintoki*, with about 9 mg lycopene on a wet weight basis could, besides tomatoes, probably serve as an additional source of lycopene in the diet. High availability and stability of lycopene is achieved in carrot products after blanching at high temperatures ($T = 90$ °C) and oxygen-free conditions.

Keywords: *Daucus carota* L. var. *Kintoki*; Oxygen free blanching; Lycopene content

1. Introduction

The *Harvard Meta Study*, (Giovannucci, 1999), evaluating 72 epidemiological studies, concluded, that there is strong evidence of a decreased risk of cancers, especially prostate gland, due to the intake of tomato or tomato products and thus high lycopene concentrations in blood plasma, respectively. Thermal processing enhances bioavailability of lycopene (Gärtner, Stahl, & Sies, 1997) but is also considered to reduce carotenoid contents in food materials and to change their chemical conformation (Shi & Le Maguer, 2000). Heat treatment during blanching disintegrates the plant tissue and destroys cellular compartments. As a consequence, valuable substances are brought into contact with other cellullar components, with oxygen, acids, light etc. and may be decomposed rapidly. As far as oxidative destruction is concerned, an oxygen-free processing could be suitable to stabilize carotenoids (Ramesh, Wolf, Tevini, & Jung, 1999).

2. Materials and methods

Lycopene containing carrots (*Daucus carota* var. *Kintoki*), cultivated in Hungary, were stored in the cold at 1 °C and 97% humidity directly after transport to FRCN, five days after harvest, respectively.

2.1. Blanching experiments

Carrots were washed, sliced (2–3 mm thickness) and blanched in a thermostatically heated stainless steel vessel filled with about 20 l of water as blanching medium, either continuously aerated with synthetic air or nitrogen gas. 250 g of carrot slices were placed in a basket within the vessel, moved up and down about 90 times per minute by an electric motor. Blanching conditions were 50, 70 and 90 °C for 15 min each with a control at 25 °C. Temperature of carrot slices and blanching media were measured via thermocouples.

2.2. Carotenoid extraction and analysis

The following extraction procedure was carried out under subdued light to prevent isomerization and photodegradation. 120 g of thermally treated carrots were mixed in a laboratory blender B400 (Büchi Labortechnik AG, Switzerland).

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Aliquots of about 20 g were further homogenated in 50 ml acetone using an Ultra Turrax T25 (IKA Labortechnik, Jahnke und Kunkel, Germany) and extraction was repeated until the carrot matrix had been colourless. Carotenoids within the combined, vacuum filtrated acetone extracts were dissolved in petrolether (boiling point 30–50 °C) using a separatory funnel. After washing with water and drying with Na_2SO_4 overnight, petrolether was removed.

Carotenoids were redissolved in hexane and quantified spectrophotometrically (λ 445 nm; $A^{1\%}_{1\ cm}$ 2.500).

HPLC-mesurement was performed after removal of hexane with a carotenoid solution in a mixture of tetrahydrofurane (THF) and water (90/10 vol%) containing 0.01% butyl-hydroxy-toluene to prevent peroxide formation of THF. The reversed-phase HPLC system used consisted of a Waters (Milford, USA) 626 quarternary gradient pump, an 717plus autosampler and column oven. Separations were achieved using analytical (250 × 4.6 mm I.D.) 5 μm polymeric C_{30}-columns (YMC, Inc., Milford, USA). Carotenoid separation was carried out at 1 ml/min using a linear gradient of methyl-*t*-butyl ether (MTBE) in methanol for 90 min (starting/end phase composition: 81% methanol, 15% MTBE, 4% water/4% methanol, 92% MTBE, 4% water). Column effluent was monitored with a Waters 996 Photodiode Array Detector at 200–600 nm. The detector was linked to a Computer with Waters Millenium chromatography software (LC Version 3.20). Quantification of carotenoids was achieved using standard curves of the all-*trans* isomers. The identities of all all-*trans* isomer peaks were assigned based on retention time and co-chromatography of authentic standards.

3. Results and discussion

The japanese carrot variety *Kintoki* contained 8.9 mg lycopene, 4.2 mg β-carotene and 0.5 mg lutein per 100 g of wet weight (mg/g_{ww}); α-carotene levels detected were below 0.3 mg/100 g_{ww}. With about 65% of total carotenoid content, lycopene was the major carotenoid. As lycopene contents of most fruits and vegetables are below 1 mg/100 g_{ww} (Shi et al., 2000) *Kintoki* carrots could serve as a good source of lycopene in addition to tomatoes normally containing about 3–5 mg/100 g_{ww} lycopene. Although some deep-red tomatoe varieties contain more than 15 mg per 100 g, the yellow varieties contain only about 0.5 mg per 100 g (Hart & Scott, 1995).

Within eight weeks of cold storage at 1 °C and 97% humidity, the raw carrots lost about 30% of their initial total carotenoid content. Lycopene content was reduced to about 60%, while only 20% of β-carotene content was lost (Fig. 1).

During blanching at temperatures between 50 and 90 °C for 15 min, however, lycopene contents remained stable. About 15% more lycopene was extractable after heat treatment at 90 °C compared to the fresh material

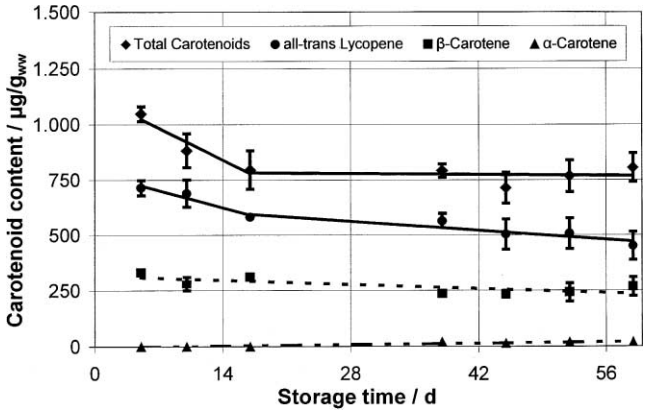

Fig. 1. Storage stability of raw carrots (error bars characterize stand. dev.).

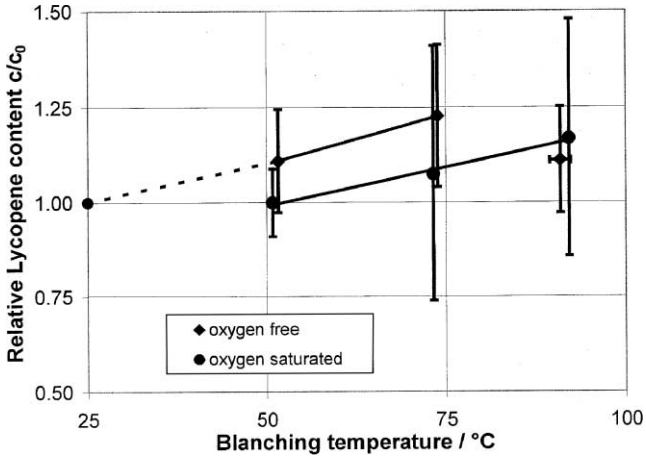

Fig. 2. Effect of blanching and oxygen on lycopene content of *Kintoki* carrots (error bars characterize stand. dev.).

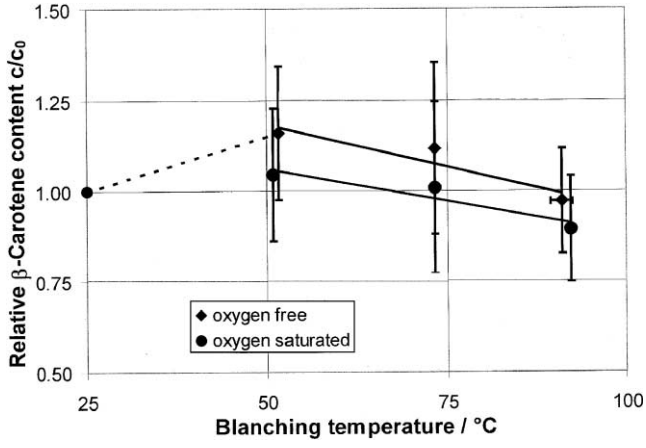

Fig. 3. Effect of blanching and oxygen on β-carotene content of *Kintoki* carrots (error bars characterize stand. dev.).

evaluated on an dry mass basis taking into account the extractive weight losses during blanching. Flushing of the blanching medium with Nitrogen to obtain oxygen-free conditions during heat treatment prevented lycopene degradation at 50 and 70 °C but not at 90 °C (Fig. 2). β-carotene content slightly decreased after treatment at 90 °C, whether oxygen was excluded or not (Fig. 3). It is supposed, that thermal treatment above 70 °C modified the carrot matrix and improved the solubility of lycopene crystals accumulated in chromoplasts.

4. Conclusions

To enhance availability and stability of carotenoids from the carrot matrix during blanching, high temperatures have to be combined with oxygen free blanching conditions. Oxygen and heat effects are subjects of further investigations, as the actual results obtained with one lycopene containing carrot variety from one cultivation have to be proofed and statistically verified.

Acknowledgements

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