Lutein Extraction from Tomato Peels and Its Evaluation of Heat Stability

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Abstract

Lutein, a yellow xanthophyll, is a very important nutritional compound in human diet because of its positive effects in the prevention of age-related macular degeneration and other eye diseases. In this study a rapid and food-grade solvent extraction for lutein content was performed on tomato peel, provided by a local tomato processing factory, with an extraction yield of lutein equal to 11.5 µg/g_{dm}. In order to evaluate its potential use as diet supplements in the preparation of functional foods the extract was heated at 50 and 100°C for 40 min and lutein percentage decrease was recorded. Heating of the extracts caused a progressive reduction of lutein, up to 30.7 and 62.8% at the end of heating for both temperatures. The colour at the end of heat treatment showed small changes, with perceptible total colour differences (Δ*E*) only for heating at high temperature.

INTRODUCTION

Commercial canning of fruits and vegetables is one of the most widespread industries with turnovers of billions of dollars, and generates enormous quantities of wastes, residues, and by-products throughout the year. Tomato (*Lycopersicon esculentum*) is one of the major vegetables, second only to potatoes in terms of world production, and canned tomato products are among the most popular worldwide. Tomato processing yields peels and tomato seeds as by-products, which represent 1-4% (w/w) of the whole tomato (Knoblich et al., 2005). This waste represents an additional cost for the tomato industries due to the high disposal costs and their strong environmental impact.

Tomato peels are an excellent source of reusable substances such as carotenoids and fibers, which might then be used in food, cosmetic and pharmaceutical industries (Kalogeropoulos et al., 2012). Carotenoids are responsible for the colour of a wide variety of foods and are important, from a nutritional point of view, because some of them have provitamin A activity. Among the principal carotenoids found in tomato fruits, lutein plays an important role in preventing cataracts and age related macular degeneration (Johnson, 2004). Lutein acts as a bluelight filter and protects the underlying tissues from phototoxic damage and is quite heat-stable.

Recently, lutein and other carotenoids in human plasma were reported to have antioxidative function such as the scavenging of free radicals and singlet oxygen and thus reducing the risk of certain cancers (Handelman, 2001; Schunemann et al., 2002). Evidences from human studies have indicated that dietary intake of lutein can increase the lutein level in plasma and the eye's retina (Bernstein, 2002).

Furthermore, lutein is authorized natural pigment that can be used as bioactive compound into various kinds of food products. The aim of this paper is to investigate the presence of lutein in tomato peel after industrial processing, in order to evaluate their potential use as nutraceutical component in the preparation of functional foods. To that end, the stability of lutein extract was evaluated during heat treatments at 50 and 100°C.

MATERIALS AND METHODS

Tomato pomace samples (peels and seeds) were provided by a local tomato processing factory (Salerno-Italy), during the production of tomato paste products by a

hot-break system. The separation of the peels from the seeds was carried out by floatation laboratory scale. In particular tomato pomace samples were dipped in water using an ultrasonic bath for 35 min at 25°C. At the end of the ultrasonic process the seeds were located at the bottom of bath, whereas the peels were on the surface. The peels were collected for following steps using a domestic sieve. The yield of the floatation was about 85%.

The tomato peels preparation was carried according to Montesano et al. (2012) with some modifications. Tomato peels were boiled in water for 10 min with ratio 1:2 sample/water. After filtration the solid residue was extracted three times with ethanol solution according to Directive 2009/32/EC. The aliquots were combined and lyophilized. The dried residue was collected and submitted to HPLC analysis for its quali-quantitative characterization. Moreover this extract was used for heat stability tests.

Heat Stability

The effect of heating on stability of lutein extract, was performed according to Albanese et al. (2014) with some modifications. The lutein extract was firstly dissolved in water; the solution of lutein (0.632 mg/L) was distributed into 30 vials which were submitted to heat stability tests. The heat stability was evaluated at two temperatures (50 and 100°C) into a thermostatic water bath for 40 min in the dark. During the heating, the vials were collected at fixed interval times and quickly cooled in an ice bath.

HPLC Analysis

Lutein content of the tomato peel after the extraction procedure and during heat treatments of extract, was performed by HPLC. After cooling, all vials were extracted three times with hexane/ethylacetate (9:1). The solvent was combined and evaporated under vacuum. The final extracts were solubilized in 1 ml of hexane/ethylacetate (9:1) before HPLC injection. The HPLC (Agilent 1100 Series Diode Array Dedector) system was equipped with C_{18} column (250 × 4.60 mm I.D., 5 μm particle) and with a precolumn (4.0 × 3.0 mm), both purchased from Phenomenex. All extracts were filtered through a 0.20 μm membrane filter to remove particulate residues before injection. 20 μl of extract was injected for HPLC analysis.

Methanol/acetonitrile (50:50 v/v) was used as a mobile phase with a flow rate of 1 ml min^{-1}. The contents of lutein was calculated by comparing the peak area with that of standard lutein.

Colour Measurements

Colour measurements of lutein extract solutions during heat stability tests were performed on the bottom of cylindrical vials using a CR-200 Chromometer (Minolta, Japan), with an aperture size of 10 mm. Colour readings were carried out on the extract solution before and after heat treatments.

In order to understand the total colour change of the extracts, CIELAB L*, a* and b* colour coordinates were recorded. The lightness value, L*, indicates the darkness/lightness of the sample, a* is a measurement of the greenness/redness of the sample and b* is the extent of blueness/yellowness. The overall colour difference (ΔE), Chroma (C) and Hue angle (H°) were calculated as follows:

ΔE: $\sqrt{(\Delta L*)^2 + (\Delta a*)^2 + (\Delta b*)^2}$

C*: $\sqrt{(a*)^2 + (b*)^2}$

H°: $tan^{-1} b*/a*$

Chroma indicates the dullness/vividness of the product while the Hue angle is how an object's colour is perceived by human eye: red, orange, green or blue.

Statistical Analysis

Experiments were performed in triplicate. Data reported were the mean and standard deviation calculated from three replicates. The analysis of variance (ANOVA)

was applied to the data. The least significant differences were obtained using an LSD test ($P<0.05$). Statistical analysis was performed using SPSS version 13.0 for Windows (SPSS, Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Tomato peels have been known to be a good source of carotenoids, principally lycopene (15-414 mg kg^{-1} dw^{-1}; Kaur et al., 2006; Kalogeropoulos et al., 2012), followed by β-carotene (15-135 mg kg^{-1} dw^{-1}; Calvo et al., 2007; Calvo and Santa Marıa, 2008) and lutein (9-14.5 $\mu g/g_{dm}$).

HPLC analysis performed on the tomato peel extract showed an extraction yield of lutein content equal to 11,5 $\mu g/g_{dm}$. Similar amounts ranging from 9 to 14.5 $\mu g/g_{dm}$ were obtained in previous studies (Montesano et al., 2012; Knoblich et al., 2005) where further purification steps on tomato peel extracted were performed.

However, the simple extraction procedure, proposed in this study, was able to obtain lutein as the principal and the most abundant carotenoid.

The stability of lutein during heating at 50 and 100°C was reported in Figure 1. In contrast to other carotenoids such as lycopene and β-carotene (Dhuique-Mayer et al., 2007; Cinquanta et al., 2010; Albanese et al., 2013; Fratianni et al., 2013), the amount of lutein showed a progressive reduction for both temperatures investigated up to about 30,7 and 62.8% after 40 min of treatment at 50 and 100°C respectively. The trend observed in our trials was in agreement with Hadjal et al. (2013) who highlighted that lutein content in different model systems decreased to the increasing of heating temperature. Different percentage decreases about the heating stability of lutein were reported in literature. Dhuique-Mayer et al. (2007) measured a percentage reduction of lutein content in citrus juice after 15 min of heating at 55°C whereas no decrease at same heating time was observed by Hadjal et al. (2013) in blood orange juice at 45 and 60°C. These conflicting results could be explained because the stability of xanthophylls and thus of lutein is influenced by other factors such as the pH of the medium, the presence of antioxidant compounds and metal catalysis coming from traces of metal ions in solvent (Britton et al., 1995).

Colour stability of carotenoids is a prerequisite for their successful application in foodstuffs. Before the heat treatment and considering the CIELAB parameters, the colour of the vials, at the concentration of tomato peel extract, used for the tests, appeared to be light yellow.

During the heat treatment, for both temperatures investigated, no significant changes ($P< 0.05$) in lightness and hue angle was observed in contrast to Chroma values (C*), which showed a progressive decrease in colour saturation with higher decrease at 100°C (Fig. 2).

The good correlation (R^2) recorded for both temperatures between lutein decrease and Chroma values highlighted that Chroma changes can be used as rapid indicator of lutein degradation in thermal process (Fig. 3). For a better measurement of the extract colour changes, the total colour difference (ΔE) was calculated. According to literature data (Berns, 2000), a perceptible difference occurs for ΔE higher than 3.5. This value is reached only at the end of heat treatment at 100°C (Fig. 3).

CONCLUSIONS

The results of this study showed that tomato peel by-products represent an alternative and low-cost source for the extraction of nutraceutical compounds such as lutein. As solvents involved during the extraction procedure proposed were food compatible, the extract may be used directly as supplement for the formulation of functional foods. Thermal treatments at high temperatures for long time increased the degradation of lutein content.

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Figures

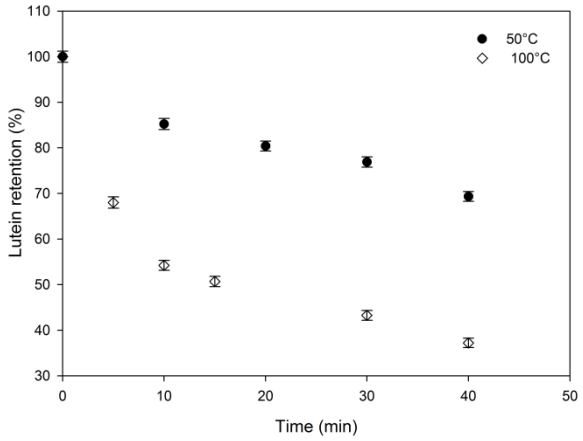

Fig. 1. Lutein retention vs. time of heat treatments at 50 and 100°C.

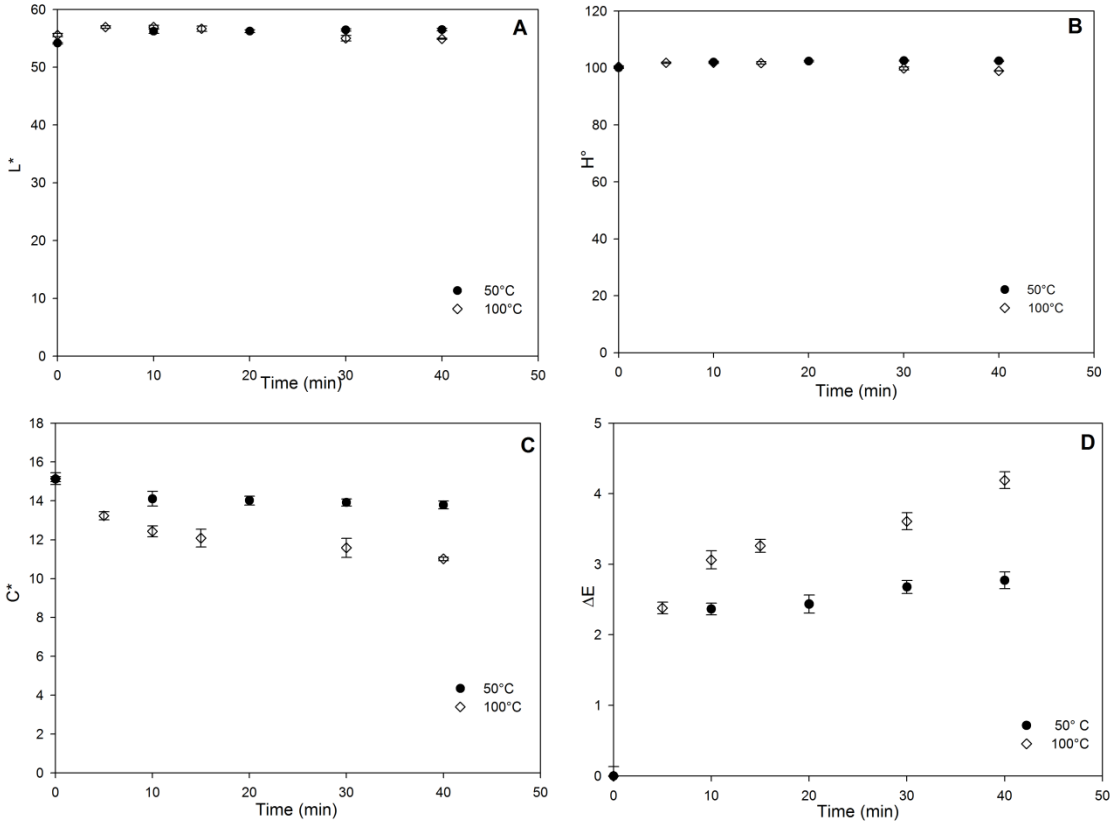

Fig. 2. Evolution of lightness (A), Hue angle (B), Chroma (C) and total colour difference (ΔE) (D) in lutein extract during heat treatment at 50 and 100°C.

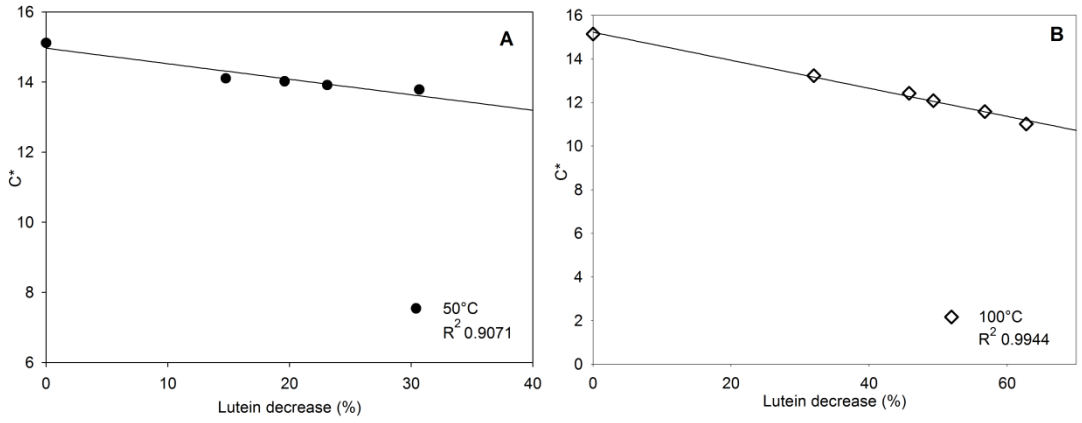

Fig. 3. Correlation between lutein and Chroma (C*) during heat treatments at 50°C (A) and 100°C (B).