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Partial dehydration of cherry tomato at different temperature, and nutritional quality of the products

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ABSTRACT

This study concerns the partial dehydration of cherry tomatoes (*Lycopersicon esculentum*, var. Shiren) to obtain a product with 25% initial water content. Two kinds of dried tomatoes were obtained using a forced air oven at 40, 60 and 80 °C for different lengths of treatment. The first type was dehydrated after immersion of the fresh tomatoes in an aqueous solution of citric acid, sodium and calcium chloride (10:10:24 g/l); the second was obtained with no pre-treatment. The products were characterised by measuring their CIE $L*a*b*$ colour parameters and levels of L-ascorbic acid, lycopene and β-carotene to evaluate thermal damage during processing under the different conditions. Moreover, water activity and the formation of 5-hydroxymethylfurfural were also determined as an index of sugar heat degradation. Treatment with a dipping solution protected both the nutritional and chemical qualities of the partially dried cherry tomatoes. Temperature was directly related to browning, ascorbic acid loss and HMF formation, while no clear influence could be found for carotenoid degradation.

1. Introduction

A significant part of cherry tomato production is concentrated in a brief period during which their value drops to below cost. Therefore, producers aim at alternatives to commercialise excess produce, hopeful of some profit. This can be achieved by creating a new product, which is stable and marketable all year round. Being a popular fruit, tomatoes find numerous uses in both fresh and processed forms. Processed products include ketchup, sauces, pastes and juice. Drying is not a popular way to process tomatoes due to its adverse effect on final product quality (Lewicki, Vu Le, & Pomarańska-Lazuka, 2002) such as tissue browning and remarkable changes in the flavour profile. Many differences in general composition have been highlighted between traditional varieties (big tomatoes) and the new small-sized varieties (cherry and plum tomatoes), the latter characterised by higher dry matter and soluble solid fraction, essentially due to the higher levels of sugars and organic acids (Muratore, Licciardello, & Maccarone, 2005).

Much research has been carried out in order to correlate the assumption of tomatoes and their derivatives, with the ability to prevent some kinds of cancers and cardiovascular diseases (Giovannucci et al., 1995; Giovannucci, 1999; La Vecchia, 1998). These studies have demonstrated that thermal treatment of tomatoes (in every commercial product) positively correlates with low risk for cancers of the digestive tract and prostate. Other works (Nakagawa, Yokozawa, Teresawa, Shu, & Raj Juneja, 2002; Russo et al., 2000) have confirmed that the consumption of natural substances capable of lowering oxidants, can protect against epithelial cancers and other diseases. Abushita, Hebshi, Daood, and Biacs (1997), Crozier, Lean, Mc Donald, and Black (1997), and Sies and Stahl (1998) have highlighted that the biological value of tomatoes is undoubtedly related to their high concentration of antioxidants, such as carotenoids, ascorbic acid and phenolic substances; in particular, lycopene acts as a "scavenger" against free radicals reducing the risk of cancer in humans.

Lycopene, according to the findings of Gartner, Stahl, and Sies (1997) and Stahl and Sies (1992), is stable during heating and industrial treatment, and treatments are able to improve lycopene bioavailability. Nevertheless, research carried out by Shi, Le Maguer, Kakuda, Liptay, and Niekamp (1999) showed significant loss in lycopene content during the dehydration of tomato products. Processes like cooking, cooling and canning do not usually cause large changes in total lycopene content, but during conventional tomato management, most lycopene can be converted from the all-*trans* form into the *cis* isomer which is less bioactive.

The aim of this work was to examine the effects of the partial dehydration of cherry tomatoes at different temperatures, in a forced air oven, with special regard to the effect of a pre-treating solution on the main physical, chemical and organoleptic characteristics of the products, namely, colour, water activity, dry matter, L-ascorbic acid, lycopene, β-carotene and 5-hydroxymethylfurfural. Many studies deal with the drying of tomatoes, but none of these has considered cherry tomatoes as a partially dehydrated product

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with 25% initial water content. Today, the market shows increasing interest in products with intermediate humidity, which combine increased stability, due to lower water activity, with good nutritional and organoleptic characteristics. Partially dehydrated cherry tomatoes could be utilised as seasoning or to replace fresh tomatoes as the main ingredient in starters and other recipes.

2. Materials and methods

2.1. Sample preparation

Cherry tomatoes, cultivar "Shiren", were collected at a local farm when ripe. They were selected by colour and homogenous diameter (29–32 mm), washed with tap water and cut longitudinally in halves.

The samples were divided into two batches, one immersed for 20 h in a solution of sodium chloride (10 g/l), citric acid (10 g/l) and calcium chloride (24 g/l) in tap water. The other was used as the control. Sodium chloride is used in ancient Sicilian tradition to prepare dried tomatoes, citric acid was used to guarantee lower pH for a longer shelf life, and calcium chloride was added because, according to a previous work, it increases the amount of water removed during dehydration (Lewicki et al., 2002).

2.2. Dehydration

Cut tomatoes were placed on four grates. Drying was performed in a forced air oven G®-Therm 075 (Galli, Milan, Italy) with the following characteristics: heating power, 1330 W; volume, 75 l; forced air speed, 2000 rpm. The following drying temperatures were chosen for treated and untreated samples: 40, 60 and 80 °C. The tomatoes were dried to 25% of their initial water content.

2.3. Quantitative measurements

For the fresh sample, pH, °Brix, dry matter and colour (CIE parameters) were determined.

The partially dehydrated cherry tomatoes (16–20 halves, 160–200 g), both raw and treated samples, were homogenised immediately at the end of drying and their dry matter and colour were measured. Samples with similar weight and dimensions were packed in PET/PP bags (Plastar Pak s.r.l., Milan, Italy) in a partial vacuum to reduce headspace, and then thermally sealed (Delta model "Delta 30", Brindisi, Italy) stored at −18 °C, and thawed at +4 °C before analysis.

All the analyses were carried out in duplicate runs: dry matter was determined for 2 g homogenised samples in a thermo ventilated oven at 105 °C until constant weight; pH was determined for five homogenised fresh fruits by digital pH meter (MP 220, Mettler Toledo, Greifensee, Switzerland); total soluble solids were measured at 25 °C by refractometer (2WAJ ABBE bench Refractometer, Optika Microscopes, Bergamo, Italy); the colour coordinates $L*$, $a*$, $b*$, C (colour chromaticity) and h (colour intensity) were measured by calorimeter NR-3000 (Nippon Denshoku Ind. Co. Ltd, Japan).

The colour of fresh cherry tomatoes was measured from the puree of 8–10 halves for both fresh and dehydrated samples. Water activity was determined at 25 °C for fresh and partially dried samples by hygrometer AwVC (Rotronic AG, Bassersdorf, Switzerland).

2.4. Carotenoids

Carotenoids were extracted according to De Sio, Grimaldi, and Loiudice (1999); in particular, for partially dehydrated samples, the initial extraction was modified as follows: 2 g were mixed with 50 ml dichloromethane/methanol 2:1 (v/v) solution with 0.1% BHT and the extraction was repeated three times, using a total of 150 ml extraction solution.

Quantification was performed by HPLC (Finnigan SpectraSystem P 2000, Thermo scientific, Waltham, MA, USA) equipped with a Diode Array Detector UV 6000 LP, a Waters-YMC C-30 column for carotenoids (5 μm, 250 mm × 4.6 mm i.d.), and a 20 μl loop. Carotenoids were separated by 95:5 (v/v) methanol/H_2O as mobile phase A and dichloromethane with 0.1% BHT and 0.05% triethylamine (TEA) as mobile phase B. The solvent program, at a flow rate of 0.8 ml/min, was: 95% A for 2 min; 95% A to 30% A linearly in 8 min; followed by 5 min isocratic; 30% A to 10% A linear increase in 5 min; 10 min isocratic and a return to 95% A at 40 min to restore the initial conditions. Triethylamine was used to reduce carotenoid misplaced in the column and to improve peak shape.

The spectra were recorded in the range 320–480 nm, while chromatograms were acquired at wavelength (λ) 480 and 460 nm to determine lycopene and β-carotene. Quantification was made by calibration using appropriate dilutions of external standard lycopene and β-carotene (Sigma-Aldrich, Milan, Italy). All solvents were HPLC grade (J. T. Baker, Deventer, Holland).

2.5. L-ascorbic acid

Ascorbic acid was extracted and quantified by HPLC according to Nisperos-Carriedo, Buslig, and Shaw (1992). HPLC separation was by Finnigan SpectraSystem P 2000 (Thermo scientific, Waltham, MA, USA)) equipped with a Diode Array Detector UV 6000 LP, a Supelcosil LC-18 (5 μm, 25 mm × 4.6 mm i.d.) column and a 20 μl loop.

Ascorbic acid was separated by 2% KH_2PO_4 buffer solution at pH 2.3 as mobile phase, at a flow rate of 0.5 ml/min. The spectra were recorded in the range 245–260 nm, where maximum absorbance for ascorbic acid is at 245 nm, but the acquisition of chromatograms was set at 260 nm to avoid interference (Finley & Duang, 1981). The identification and quantification was made by the external standard method, using a pure commercial standard (Carlo Erba Reagenti, Milan, Italy).

2.6. 5-Hydroxymethylfurfural (HMF)

The extraction of HMF was performed by homogenising 10 g of sample with 20 ml HPLC grade water for 15 min; samples were filtered through 0.45 μm nylon filters, and injected into the HPLC. The HPLC was a Varian 9012Q liquid chromatograph equipped with a diode array detector (Varian, Star 330), a Merk Lichrospher 100 RP-18 (5 μm, 125 mm × 4 mm i.d.) column, and a 20 μl loop. HMF was separated using H_2O/acetonitrile 95:5 (v/v) as mobile phase, at a flow rate of 1 ml/min. Chromatograms were acquired from 250 to 300 nm but HMF was monitored at 285 nm. Quantification was performed by external standard calibration using a calibration line obtained with appropriate dilutions of commercial standard (Sigma, Milan, Italy). Water and acetonitrile were HPLC grade (Merck, Darmstadt, Germany).

2.7. Statistical analysis

All analyses were carried out in duplicate. The experimental data was processed by Duncan test using Statgraphics Plus 5.1 software (Manugistic Inc. Rockville, MD, USA). The means and standard deviations were calculated. The data shown is the average of all repetitions. The sets of data obtained for each parameter were statistically treated to obtain a 95% confidence interval.