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Quality of carrot juice as influenced by blanching and sonication treatments

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ABSTRACT

A study was conducted to evaluate the influence of blanching and sonication on important quality parameters of carrot juice. Blanching of carrots was done in normal water and acidified water (45 g/L citric acid, pH 1.3) at 100 °C for 4 min and juice was extracted. Sonication of juice was done (frequency 20 KHz and amplitude level 70%) at 15 °C for 2 min. Significant increase ($P < 0.05$) was observed in total carotenoids, lycopene and lutein in blanched samples, however, this increase was more in simultaneously blanched and sonicated samples. Additionally, highest increase was observed in all these pigments as a result of combined treatment of acid blanching and sonication. Sucrose, glucose, fructose, chlorogenic acid and mineral elements (Na and K) were decreased significantly in all blanched samples while increased significantly ($P < 0.05$) in all sonicated samples. Significant decrease was observed in some minerals (P and Mg), total plate count, yeast and mold in all samples treated with blanching and sonication but this decrease was more in samples treated with acid blanching and sonication. The results suggest that combined treatment of blanching and sonication may successfully be employed for processing of carrot juice to improve quality.

1. Introduction

Carrot (*Daucus carota* L.), an important root vegetable of Umbelliferae family, is cultivated throughout the world. Carrot and its products including juices are widely accepted as a rich source of phytonutrients such as bioactive compounds, carotenoids, minerals and vitamins (Qin, Xu, & Zhang, 2005) which provide many health benefits to the human body.

Quality of an end product, in part, depends on the processing methods. Blanching is an important step for the processing of vegetables and vegetable products including juices to preserve color, inactivate enzymes and microbes, remove entrapped air and make protopectin soluble (Bahçeci, Serpen, Gökmen, & Acar, 2005; Barrett & Theerakulkait, 1995; Bourne, 1976). All these benefits of blanching depend on the heat supplied to the product but it also adversely affects the texture, heat sensitive nutrients, water soluble contents and ultimately the quality and bioactivity of the end product (Mizrahi, 1996; Wennberg, Ekvall, Olsson, & Nyman, 2006). Due to scientific evidences and increasing knowledge, consumers now want food not only with extended shelf life but also with improved quality and safety.

In order to fulfill the consumer's demand, researchers are looking for such food processing techniques that could not only retain but also improve the nutritional value of fruit juices (Bhat, Ameran, Voon, Karim, & Tze, 2011; Bhat, Kamaruddin, Min-Tze, & Karim, 2011). Sonication is such a novel non-thermal food processing technique that can meet the demands by enhancing health related nutrients and other quality attributes of fruit juices (Abid et al., 2013; Bhat, Ameran, et al., 2011; Rawson et al., 2011).

The product can be treated with ultrasound that offer improvements in these nutrients in order to recover the losses of desirable nutrients occurred during blanching, and consequently, benefits of both techniques can be obtained simultaneously. Keeping all these backdrops in focus, the present study was initiated to evaluate the effects of combined treatments of blanching and sonication on the coloring pigments (total carotenoids, lycopene and lutein), sugars (sucrose, glucose and fructose), mineral elements (Na, K, P and Mg), chlorogenic acid and microbial stability of carrot juice.

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2. Materials and methods

2.1. Chemicals

Chlorogenic acid, lutein, glucose, fructose and β-carotene were purchased from Sigma Aldrich Chemie GmbH (Steinheim, Germany). Sucrose was purchased from Fluka Chemie GmbH (Buchs, Switzerland). Formic acid and acetonitrile were obtained from Sinopharm Chemical Regent Co., Ltd (Shanghai, China). HPLC grade methanol was purchased from Hanbon Science and Technology (Jiangsu, China). Sodium sulfate was purchased from Xilong Chemical Factory (Shantou, China). Citric acid and butylated hydroxyl-toluene (BHT) were obtained from Sinopharm Chemical Regent Co., Ltd (Shanghai, China). Acetone was purchased from Lingfeng Chemical Reagent Co., Ltd (Shanghai, China). Nitric acid, hydrogen peroxide, petroleum ether and n-hexane were purchased from Nanjing Chemical Reagent Co., Ltd (Nanjing, China). All other chemicals used were of analytical grade.

2.2. Collection of raw material and blanching

Fresh good quality carrots were procured from vegetable market of Nanjing, China. Carrots were washed, peeled and sliced manually with stainless steel knife. The sliced carrots were divided into three parts. First part without blanching was selected as control, second and third parts were blanched in hot water and acidified water (citric acid of 45 g/L, pH 1.3) respectively, at 100 °C for 4 min. Then, blanched carrots were cooled to a room temperature by dipping in cold water.

2.3. Juice extraction and sonication treatment

Juice was extracted by using domestic juice extractor of MJ-M176P (Panasonic Manufacturing Berhad, Malaysia) and filtered through muslin cloth to avoid impurities and coarse particles. The juice was then sonicated (250 mL in a 500 mL jacketed vessel, 7.6 cm ID × 9.3 cm OD × 13.5 cm Depth × 14.9 cm Height) by using ultrasonic processor of 750W (VC 750, Sonics and Materials Inc., Newtown, CT, USA) with 0.5 inch probe for 2 min by adjusting the pulse duration of 5 s on and 5 s off at a frequency of 20 kHz and amplitude level of 70%. The ultrasonic intensity measured by using HI 9063 thermocouple (Hanna Instruments Ltd., Leighton Buzzard, UK) was 48 W cm^{-2}. Temperature was maintained at 15 °C by automatic control unit. The schematic diagram of exposure system is shown in Fig. 1. The ultrasound probe was immersed 2 cm in depth with respect to the liquid surface. Sonication treatments were performed in darkness to avoid any interference of light with samples and carried out in triplicate. Fresh untreated juice was selected as control. All the juice samples were stored in air tight sterilized 250 mL media bottles at 4 °C for 48 h until further analysis. The scheme of different treatments was as: control, sonicated, WB: water blanched, WBS: water blanched and sonicated, AB: acid blanched, ABS: acid blanched and sonicated.

2.4. Determination of total carotenoids

Total carotenoids were determined by the method of Liao et al. (2007) with slight modifications. Juice sample (25 mL) was taken in a separation funnel and then 80 mL of n-hexane/acetone (1:1, v/v) was added in it, shook well and held for 5 min. After separation, organic phase was extracted. Aqueous phase was repeatedly extracted by using 15 mL of n-hexane/acetone (1:1, v/v) until it became colorless. The organic phase was dehydrated by adding anhydrous sodium sulfate in it. Total carotenoids were determined at 450 nm by using a spectrophotometer (Shanghai Jinghua Science & Technology Instruments Co., Ltd, China) at ambient temperature. Standard solution of β-carotene with concentrations (2–10 μg/mL) was prepared. The results were expressed as μg β-carotene equivalent/mL of sample by plotting a standard curve.

2.5. Determination of lycopene

Lycopene was determined by using a method reported by Oliu, Serrano, Fortuny, and Belloso (2009) with some modifications. Juice sample (0.6 mL) was added to 5 mL of BHT in acetone (0.05:99.95, w/v), 5 mL of ethanol (95:5, v/v) and 10 mL of n-hexane. The mixture was centrifuged for 15 min at 320 g. After shaking, 3 mL of distilled water was added in it. The vial was then agitated for 5 min and held for 2 min to allow phase separation at room temperature. The absorbance of upper, n-hexane layer was determined using a spectrophotometer at 503 nm blanked with hexane. Following equation was used to calculate the lycopene content of each sample.

$$\text{Lycopene} = (\Delta 503 \times \text{MW} \times \text{DF} \times 1000))/(\varepsilon \times L)$$

where MW is the molecular weight of lycopene (536.9 g/mol), DF is the dilution factor, L is the path length in cm and ε (172,000 L/mol

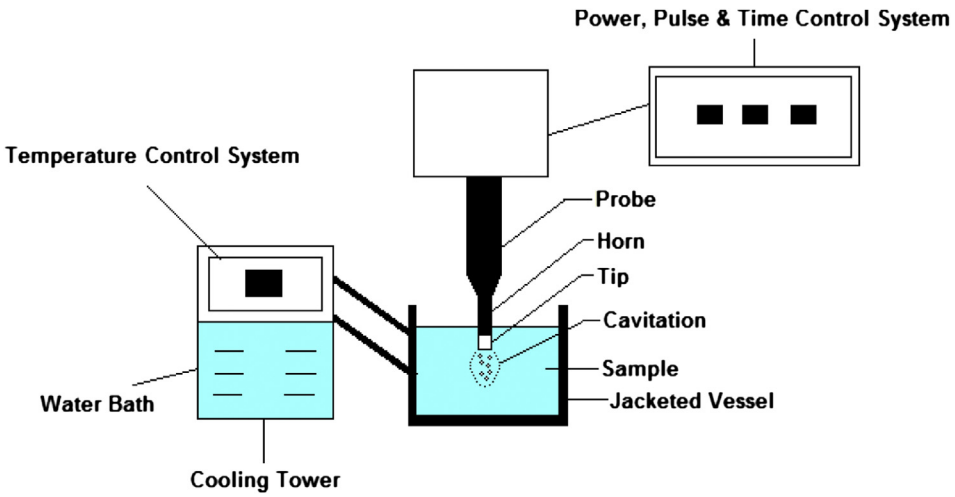

Fig. 1. Schematic diagram of probe type sonication exposure system.