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Effect of high pressure processing on the stability of anthocyanin, ascorbic acid and color of Chinese bayberry juice during storage

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ABSTRACT

The stability of anthocyanin (Cy3Gl) and ascorbic acid (AA) of pressure treated Chinese bayberry (*Myrica rubra Sieb.* et Zucc.) juice was investigated during storage at temperature of 4 °C and 25 °C. Samples of Chinese bayberry juice (350 mL each, packed with a polyethylene bag) were processed at 400, 500, 600 MPa in room temperature for 10 min. The retention ratio of Cy3Gl and AA content after pressure treatment was more than 98% and 96%, respectively. Both Cy3Gl and AA of pressure treated juice were more stable during storage as compared to those of the untreated control juice. The degradation of Cy3Gl and AA of samples during storage could be described using first order kinetic model. It was observed that there was a significant ($p < 0.01$) correlation between changes of Cy3Gl and AA content for all tested samples of Chinese bayberry juice during storage.

1. Introduction

Chinese bayberry (*Myrica rubra Sieb.* et Zucc.) is one of the bayberry fruits native to China with high commercial value. Consumers seem to be primarily attracted by the red to purple color, special sweet, sour taste and exquisite flavor of the fruit. Unfortunately, due to ripening in hot and rainy season (June and July), Chinese bayberry is highly susceptible to mechanical injury and microbiological decay, which limit its postharvest life to 1–2 days. Even if it is stored in a cooler (4 °C), its bioactive components still decrease rapidly, and only 5 days can be kept for shelf life (Zhang et al., 2008). Therefore, there is a demand for alternative processes for shelf-life extension or for developing other products, such as Chinese bayberry juice.

It has been reported that Chinese bayberry juice has strong antioxidant capacity associated with anthocyanins, phenolics, and ascorbic acid (Bao et al., 2005; Fang et al., 2006; Yang et al., 2009). For fruit juice, it is very important to retain its fresh like color, flavor and qualities. The red color of Chinese bayberry juice is mainly due to the presence of anthocyanins, especially cyaniding-3-glucoside (Ye et al., 1994). Consumption of fruit and vegetable juices containing anthocyanins and ascorbic acid can reduce various degenerative diseases (Torres et al., 2011). However, anthocyanins and ascorbic acid are very sensitive to heat, and conventional thermal processing may cause detrimental quality changes in color, flavor, and texture of the product (Polydera et al., 2004; Cortés et al., 2008).

With the increase of consumer demand to food quality, it is necessary to develop innovative processing techniques that use minimal heat and additives and result in fresh like products of superior nutritional quality (Rastogi et al., 2007). High pressure processing (HPP) is an alternative processing technology to inactivate microorganisms with high retention of color, flavor and nutritional parameters of fruit and vegetables due to its limited effect on the covalent bonds of low molecular-mass compounds (Cheftel, 1995; Patras et al., 2009).

Little information has been reported about HPP effect on anthocyanins, ascorbic acid of Chinese bayberry juice, although literature data is available related to HPP effect on the quality of various other fruit products, such as orange juice, tomato puree, carrot puree, strawberry juice, blackberry juice (Polydera et al., 2003; Rodrigo et al., 2007; Patras et al., 2009; Verbeyst et al., 2010). It is generally considered that pressure alone does not cause significant change in ascorbic acid concentration of fruit juice. By using HPP, the shelf life of fruit juices can be extended compared to that of untreated juices (Ahmed et al., 2004; Polydera et al., 2005). Although kinetic studies on nutrients during storage have been reported on other berry fruits like strawberry, blackberry, and blueberry, no one has been found on Chinese bayberry.

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The objectives of this study were (1) to evaluate the effect of HPP on the anthocyanin, ascorbic acid and color of Chinese bayberry juice, (2) to analyze degradation kinetics of the anthocyanin and ascorbic acid in HPP treated bayberry juice during storage, and (3) to investigate the correlation between anthocyanin, ascorbic acid and color changes during storage.

2. Materials and methods

2.1. Preparation of Chinese bayberry juice

Fresh Chinese bayberries were purchased from a local fruit market (Hangzhou, China). Bayberry juice was obtained by squeezing the fruit with a juice extractor (JYZ-B550, Hangzhou, China), and it was then centrifuged at 3630xg for 10 min using a centrifuge (GL-22M, Saite Xiangyi centrifuge Ltd., Hunan, China). The supernatants were filtered through a 0.23-mm-pore-diameter filter. The juice was aseptically packaged with polyethylene bags and stored at −20 °C until used.

2.2. High pressure treatments

High pressure treatments were performed using a laboratory-scale equipment (UHPF-750, Kefa, Baotou, China) with a maximum capacity of 5 L and a potential maximum pressure of 750 MPa. Distilled water was used as pressure-transmitting medium. After thawing over night at 4 °C, the juice was vacuum packed using polyethylene bags (350 mL each). Samples were placed into the high pressure vessel and subjected to pressure treatments at 400, 500 or 600 MPa for 10 min at room temperature. The pressure come-up rate was about 200 MPa/min and the time of depressurization was less than 10s.

2.3. Sample analysis

Anthocyanin, L-ascorbic acid, color, pH, soluble solid content of samples were analyzed right after HPP treatment and during storage at 4 °C for 25 days and 25 °C for 8 days. Samples without HPP treatment were used as control. For each treatment, all measurements were carried out in triplicate.

Anthocyanin content of bayberry juice was determined using pH differential method (Giusti and Wrolstad, 2001). Absorbance was measured by a spectrometer (TU-1810, PERSEE, Beijing, China) using wave length of 510 and 700 nm. Anthocyanin was calculated as cyandin-3-glucoside using an extinction coefficient of 26,900 L/cm/mg and a molecular mass of 449.2 g/mol. Ascorbic acid of bayberry juice was analyzed by a titrimetric method by using 2,6-dischloroindophenol (AOAC, 1975).

Color of bayberry juice was measured in reflectance mode at ambient temperature using a Chromameter (CR-300, Minolta, Japan). The tristimulus CIE values of L, a, and b were obtained for each test. The total color change between samples and the control (ΔE) was calculated by following equation (Barreiro et al., 1997):

$$\Delta E = \sqrt{(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2} \quad (1)$$

where L and L_0 are lightness of sample and control, respectively; a and a_0 are redness of sample and control, respectively; b and b_0 are yellowness of sample and control, respectively.

The pH was determined based on the potentiometric measurement at 20 °C using a Crison GLP 21 pH meter (PB-10, Sartorius, Germany) equipped with a temperature compensation sensor at 20 °C. The soluble solids content (SSC) was measured with a portable refractometer (PR-201α, Atago, Japan). One drop of juice was placed on the refractometer glass prism and the SSC was obtained as percentage (%).

2.4. Data analysis

Chemical or biochemical reaction of compounds in food materials has been described as a first-order model by several reporters (Polydera et al., 2003; Verbeyst et al., 2010; Torres et al., 2011). In this study, the first-order model was used for the degradation of anthocyanin and ascorbic acid during storage.

$$C_t = C_0 e^{-Kt} \quad (2)$$

where C_t (mg/100 mL) is the concentration of anthocyanin or ascorbic acid at any given time (t), and C_0 is initial concentration. K is reaction rate constant ($1/d$).

Statistical analysis was done using one-way analysis of variance (ANOVA). Pearson correlations of different parameters were conducted using SPSS 20.0 (SPSS Inc., Chicago, US). Tukey test ($p < 0.05$) was applied to compare the average values obtained.

3. Results and discussion

3.1. Physical and chemical properties

Table 1 shows the physical and chemical properties of Chinese bayberry juice tested right after pressure treatments as compared with the control (without pressure treatment). The pH value of the control was 2.83 ± 0.01, a little bit less than that reported in other studies (Fang et al., 2006; Yang et al., 2009). No significant pH difference ($p < 0.05$) was observed between pressure treated samples and the control. This is consistent with observations for pressure treated apple puree by Landl et al. (2010).

During storage, pH value varied with time for both pressure treated samples and the control, especially during storage at 25 °C (Table 2). In general, pH of pressure treated juice demonstrated more stable than that of the control. Storage at 4 °C resulted in much less change in pH than that at 25 °C. Therefore cooling storage is still necessary for a longer shelf life of Chinese bayberry juice after pressure processing.

No significant difference of the SSC was found between HPP treated juice and the control (Table 1), meaning that the impact of HPP on the SSC of Chinese bayberry juice was not obvious. The SSC of pressure treated juice appeared stable during storage (Table 2). However the SSC of the control decreased rapidly in 2-day storage at 25 °C, which may be related to microbiological deterioration in the juice.

3.2. Cyaniding-3-glucoside

Cyaniding-3-glucoside (Cy3Gl) was identified as a major anthocyanin in Chinese bayberry, representing more than 95% of total pigments (Ye et al., 1994). The Cy3Gl in the control juice was determined at 28.76 mg/100 mL (Table 1), close to that observed

Table 1
Physical and chemical properties (mean ± SD, $n = 3$) of Chinese bayberry juice after high pressure treatments.

Treatment	Control	400 MPa	500 MPa	600 MPa
pH	2.83 ± 0.01a	2.84 ± 0.01a	2.83 ± 0.01a	2.84 ± 0.01a
SSC (%)	9.8 ± 0.01a	9.9 ± 0.01b	9.9 ± 0.00ab	9.9 ± 0.06ab
L	31.60 ± 0.11a	30.84 ± 0.34b	30.99 ± 0.24ab	30.97 ± 0.30b
a	15.18 ± 0.30a	14.35 ± 0.21ab	13.70 ± 0.16bc	12.95 ± 0.63c
b	−2.98 ± 0.19a	−3.36 ± 0.06ab	−3.60 ± 0.11bc	−3.85 ± 0.36c
Cy3Gl (mg/100 mL)	28.76 ± 0.48a	28.41 ± 0.42a	28.10 ± 0.40a	28.18 ± 0.43a
AA (mg/100 mL)	21.21 ± 1.24a	17.26 ± 0.72b	21.10 ± 1.25a	20.38 ± 4.85ab

Different letters (a, b, c) in the same row indicate significant difference ($p < 0.05$) between treatments.