Effects of pretreatment on the quality and stability of blueberry juice

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Abstract. Quality and stability in blueberry juice were studied with cold pretreatment and freeze-thaw pretreatment. Samples were pretreated in cold temperature environment and the cloud value of juice was significantly decreased \( (P<0.05) \). Meanwhile, the cloud value of juice was significantly increased when the blueberries were processed by freeze-thaw pretreatment \( (P<0.05) \). The juice of \( a^* \) and \( L^* \) value were significantly increased in freeze-thaw pretreatment and significantly decreased in cold pretreatment \( (P<0.05) \). The turbidity of the juice which blueberries were processed by cold pretreatment was 680 NTU that it was significantly decreased than other samples \( (P<0.05) \). The particle diameter of blueberry juice was decreased by cold pretreatment. A cold pretreatment blueberry to process juice most effectively retained the stability of juice and minimized color change.

1. Introduction

The blueberry belongs to the family Ericaceae, subfamily Vaccinoideae. They have a wide area of cultivation in China. Blueberry is rich in flavonoids, tannins and phenolic acids\[1\]. It is known for its elevated antioxidant capacity against free radicals and reactive species, being considered as one of the best sources of antioxidants in the diet\[1\]. Blueberries are highly appreciated for their quality but susceptibility to microbial decay, mechanical damage, and moisture and nutritional loss\[2\]. It is reported that fresh blueberries have a shelf life of 1-8 weeks depending on stage of fruit ripeness, method of harvest, presence of fruit disease, and storage conditions\[3\]. Because of it, more than fifty percent of harvested blueberries are processed into juice, purees and other blueberry products\[4\].

Transfer from producer to consumer generally requires 5-10 d, which necessitates low-temperature storage \[2\]. Meanwhile, the storage of blueberry is the most important link to ensure the quality and nutrition of blueberry juice. Nowadays, there are the two most common low-temperature storage methods: cold storage and frozen storage. Cold storage is characterized by a reduction in temperature of a food to between -1 °C and 8 °C, so as to decrease enzymatic and microbial activities, conferring a longer shelf life on the product. Frozen storage is characterized by a reduction in temperature of the food to below its freezing point, thus increasing the preservation time by reducing the water activity to keep freshness\[5\].

The objectives of the present study were to analyze the quality and stability of blueberry juice prepared by different pretreatment methods, and to evaluate the relationship between the pretreatment temperature and juice quality. The best pretreatment processing which could maintain the nutrition and stability of juice were chosen.

2. Material and methods

2.1. Fruit materials and juice preparation
The blueberries (Vaccinium spp. LanFeng) of similar sizes and colors, without diseases or mechanical injuries, were purchased from a local fruit distribution center in Jinzhou, Liaoning. The selected blueberries were randomly distributed into three groups for different pretreatment. The first group of blueberries were stored at 4 °C (cold pretreatment), and then squeezed out juice. The other group of blueberries were frozen for more than 48 h in a refrigerator at -18 °C thawing at 4 °C (freeze-thaw pretreatment), and then squeezed out juice. The control group were juiced by fresh blueberries. Every juices were pasteurized using the water bath (HH-6, Jieruier, China) until the inside core reached 90 °C for 2 min and collected in sterile jars [6]. All processed juices were then stored at 4 °C.

2.2. Total soluble solid and cloud value
TSS, expressed in °Brix, was determined using a digital refractometer (Pal-3, Atago Co, Ltd, Tokyo, Japan). The blueberry juice samples were centrifuged at 760 × g for 10 min and the absorbance of the supernatant was measured at 660 nm using a spectrophotometer (UV-1801, Shimadzu, Japan) to determine the cloud value [7].

2.3. Color
Color was measured with a Chroma meter (CHROMA METER CR-400, Konica Minolta, Japan). All samples were measured L* values, a* values, b* values, ΔE (the total color), h°ab (hue, attribute related to the differences in absorbance at different wavelengths and considered the qualitative attribute of color), and C°ab (chrome, quantitative attribute of colorfulness) [8].

\[
h_{ab} = \arctan\left(\frac{b^*}{a^*}\right)
\]

\[
C_{ab} = \left[(a^*)^2 + (b^*)^2\right]^{1/2}
\]

2.4. Turbidity
Turbidity is an index to evaluate the degree of light scattered by particles (suspended solids) in water or other liquids. It was directly measured in a transparent glass tube of 30 mL using the nephelometer (WGZ-2000, INESA, China) at room temperature. The results were expressed as nephelometric turbidity units (NTU) [9].

2.5. Particle size distribution (PSD)
The Particle size distribution (PSD) was determined by the BT-9300ST Mastersizer (Better Instrument Co Ltd, Jinzhou, Liaoning, China). Laser light diffraction was used to measure particles from 0.1 to 1000 μm [10].

2.6. Statistical analysis
All the values provided are the average of at least six replicates and to determine the significant differences of the results an analysis of variance was carried out. Analysis and drawing was performed using SPSS 18.0 and Origin 8.5 significance was determined at 95% confidence (P<0.05).

3. Results and discussion

| Pretreatment method       | TSS      | Cloud value |
|---------------------------|----------|-------------|
| Control treatment         | 8.37±0.06a | 0.57±0.02b  |
| Cold pretreatment         | 8.43±0.06a | 0.52±0.02b  |
| Freeze-thaw pretreatment  | 8.47±0.12a | 0.64±0.01a  |

Values with different superscript letters in a column are significantly different (P<0.05).
### Table 2. Effect of pretreatment on the color of blueberry juice.

| Pretreatment                | $L^*$   | $a^*$   | $b^*$   | $C^{ab}$ | $h^{ab}$ | $\Delta E$ |
|-----------------------------|---------|---------|---------|----------|----------|------------|
| Control treatment           | 20.41±0.56$^b$ | 1.27±0.24$^b$ | 5.57±0.28$^a$ | 5.71±0.31$^a$ | 1.35±0.03$^b$ | 16.50±0.53$^b$ |
| Cold pretreatment           | 18.83±0.25$^c$ | 0.87±0.20$^c$ | 5.51±0.25$^{ab}$ | 5.58±0.26$^a$ | 1.41±0.03$^c$ | 14.88±0.21$^c$ |
| Freeze-thaw pretreatment    | 21.89±0.81$^a$ | 2.45±0.15$^a$ | 5.24±0.19$^b$ | 5.78±0.20$^a$ | 1.13±0.02$^c$ | 18.18±0.20$^a$ |

Values with different superscript letters in a column are significantly different ($P<0.05$).

Figure 1. Effect of pretreatment on the turbidity of blueberry juice.

Figure 2. Effect of pretreatment on the particle size distribution of blueberry juice.
Blueberry juice samples were characterized by measuring the following TSS and cloud value were shown in Table 1. There were no significant differences on TSS of blueberry juice with different pretreatment ($P>0.05$). However, the cloud value of different pretreatment samples were significantly different ($P<0.05$). Compared to fresh sample, juice were processed by freeze-thaw pretreatment blueberries, the cloud value of juice was significantly increased ($P<0.05$). The results of the CIE-$L^*$, $a^*$, $b^*$ parameters, psychrometric coordinates chrome ($C_{ab}^*$), and hue ($h_{ab}^*$) were shown in Table 2. In comparison to the juice in control treatment, the $L^*$ values and $a^*$ values of blueberry juice were decreased in cold pretreatment but increased in freeze-thaw pretreatment. While a contrary result was observed for $b^*$ values. Especially, the $b^*$ values of juice was significantly decreased with freeze-thaw pretreatment ($P<0.05$). The $C_{ab}^*$ values of difference pretreated blueberry juice was insignificant. On the basis of hue ($h_{ab}^*$), resulting significant increased in cold pretreatment and decreased in freeze-thaw pretreatment ($P<0.05$). Based on $\Delta E$, the color difference pretreatment was noticeable, juice was significantly increased in freeze-thaw pretreatment and significantly decreased in cold pretreatment ($P<0.05$), indicating that pretreatment induced largely visible color changes.

Figure 1. showed the turbidity of blueberry juice. The turbidity of the juice sample which blueberries were significantly decreased than others ($P<0.05$). The samples were freeze-thawed pretreatment, showed a significantly higher turbidity than others, was 3025 NTU. These results showed that different pretreatment had significant effect on blueberry juice. The juice with cold pretreatment had lowest turbidity of 680 NTU. Figure 2. illustrated the effect of pretreatment on PSD of blueberry juice. The PSD of blueberry juice in control treatment was similar to in cold pretreatment, which was observed a smaller volume peak was appeared at around 35 $\mu$m. On the one hand, blueberry juice in cold pretreatment could be observed a monomodal and a more narrow PSD. On the other hand, the volume peak of sample by freeze-thaw pretreatment was significantly moved to larger particle. As expected, cold pretreatment significantly reduced the diameter of the suspended particles ($P<0.05$).

4. Conclusion
In this study, the effect of pretreatment on quality and stability properties of blueberry juice were evaluated. The juice were processed by cold pretreatment blueberries which had significantly improved the stability properties. PSD analysis showed that cold pretreatment significantly decreased the particle diameter of blueberry juice ($P<0.05$). Correspondingly, the turbidity and cloud value of blueberry juice in cold pretreatment were significantly lower than that of other treatments ($P<0.05$). The TSS and color were decreased after cold pretreatment. The best pretreatment processing was cold pretreatment could maintain the nutrition and stability of juice were chose.

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