Effect of Different Retailing Methods on Quality of Sweet Cherry after Forced-air Cooling and Low Temperature Transportation

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Abstract. Sweet cherry packaged in plastic clamshell containers within carton were retailed using four different methods, including 0°C with humidification (relative humidity 90-95%) and 4°C with humidification (relative humidity 90-95%) in closed refrigerated displays, opened refrigerated displays (18-21°C) and room temperature displays (27-29°C) for 2 days after forced-air cooling from 27°C to 3°C and 3 days transportation at 0°C. The result showed that the sensory evaluation score of sweet cherry retailed 2 days with the four retailing methods were 8.2, 8, 7, 5.1, respectively. The sweet cherry retailed at 0°C with humidification had lower weight loss, respiration rate and ethylene release rate and higher firmness and higher content of vitamin C, soluble solid and titratable acid compared with other treatments, and the date were 0.64%, 53.89 mgCO₂·kg⁻¹·h⁻¹, 0.06 uLkg⁻¹·h⁻¹, 2.83 kg·cm⁻¹, 151.34 mg·100g⁻¹, 20.4%, 0.7%, respectively.

Introduction

Sweet cherry (Prunus avium L) is one of the most appreciated temperate fruits by consumers [1]. Fruit visual appearance, colour, peduncle freshness, firmness, sweetness and fruit weight are the major determinants of fresh sweet cherry fruit at the retail stage [2, 3]. After harvest, the sweet cherries deteriorate rapidly, such as fruit skin colour changes, weight loss, softening and loss of nutrition, which influence the purchase decision of consumers [4]. The shelf life of sweet cherry was only 5-7 days at room temperature [5], and higher temperature resulted in higher respiration rates, which in turn increased the loss of fruit quality. In some cases, sweet cherries do not reach consumers at highly quality due to the highly perishable. So, the postharvest cold chain treatment used to maintain the quality of sweet cherry is a major research direction in recent years.

The cold chain preservation is one of safest physical preservation methods today. The first key of sweet cherry cold chain is precooling, which used to remove the field heat rapidly and reduce deterioration during transportation or storage [6]. F.G. Mitchell researched the sweet cherry delayed 3-4h and 6-7h for precooling, and then transported 5d at 0°C, and retailed 3d at 20°C, showed that the faster precooling the higher nutrition [7]. So, the sweet cherry should be precooled within 4 hours after harvest and the suitable precooling method is forced-air cooling. After precooling, cold transportation and retailing are important link of fruits and vegetables to keep fresh during distribution, but the link is weak.

In this paper, the sweet cherry after forced-air cooling and 3d transportation at 0°C were retailed with four different methods to determine the best retailing method to extend shelf life and keep good quality of sweet cherry. The quality changes in sensory evaluation, weight loss rate, firmness,
respiration rate, ethylene production rate and content of TSS, TA and VC were measured.

Materials and Methods

Materials and Treatments

“Xianfeng” sweet cherry with 9 mature were harvested in the morning from Tongzhou city in Beijing, China on 12 June 2016 and immediately transported to laboratory in 2 hours. In there, fruit were selected for uniformity of size, ripeness and were randomly packaged in plastic clamshell containers (Size: 20×10×12cm; vent area: 8.5%) within carton (Size:40×20×25cm ; vent area: 5%). The core temperature of sweet cherry decreased to 3℃ by forced-air cooling. And then, the sweet cherry was transported at 0℃ for 3d and retailed at 0℃ with humidification (relative humidity 90-95%) (M1) and 4℃ with humidification (relative humidity 90-95%) (M2) in closed refrigerated displays, opened refrigerated displays (18-21℃) (M3) and room temperature (27-29℃) (M4) displays for 2d, respectively.

Sensory Evaluation

A trained panel consisting of 3 people evaluated the sensorial quality of the samples. Visual quality of sweet cherry was scored on a 9 to 1 scale, where excellent, freshly=9; very good=7; good, limit of marketability=5; fair, limit of usability=3 and poor, unusable=1, where 6 is considered the minimum for salability [8].

Weight Loss

Weight loss was measured according to the following formula: Weight loss (%) = (original weight-weight after storage) ×100/original weight.

Respiration Rate and Ethylene Production Rate

Respiration rate was determined using an infrared CO$_2$ analyzer, according to the method of Zhao et al [9]. Ethylene production rate was measured by gas chromatograph Agilent 7820A, according to the method of Li et al [10].

Firmness

Firmness of sweet cherry were measured in 6 mm probe of a digital force gauge (FT-02, Facchini, Italy).

Vitamin C (Vc)

Vitamin C content was determined by molybdenum blue colorimetric method [11].

Total Soluble Solid (TSS) and Titratable Acidity (TA)

TSS content of fruits were determined by Atago PR-100 refractometer (Atago Co. Ltd., Tokyo, Japan) at room temperature. TA content of sweet cherry was titrated with 0.05 mol/L NaOH to the point of pH 8.1. Volume of NaOH was recorded and percent TA was calculated [12].

Statistical Analysis

Statistical analysis was done by statistical product and service solution (SPSS 13.0). The data obtained from each treatment of differences during storage were analyzed by analysis of variance (ANOVA) test and then least significant difference (LSD) test ($P<0.05$).

Results and Discussion

Sensory Evaluation and Weight Loss

The sensory evaluation score of sweet cherry after forced-air cooling and 3d transportation at 0℃ from 9 decreased to 8.9 and 8.5, respectively. After 2d retailing, the scores of sweet cherry with M1, M2, M3 and M4 methods were 8.2, 8, 7 and 5.1, respectively (Fig. 1(1)). The result showed that
low temperature had significantly \( (P < 0.05) \) maintained the sensory evaluation score of sweet cherry on the 2d retailing, while no significant difference was found between M1 and M2 \( (P > 0.05) \).

![Figure 1](image1.png)

**Figure 1. Effect of Different Retailed Methods on Sensory Evaluation and Weight Loss of Sweet Cherry.**

Weight loss is one of the main indicators of sweet cherry freshness and increased over time (Fig. 1(2)). The weight loss of sweet cherry after forced-air cooling and 3d transportation at 0℃ were 0.11% and 0.37%, respectively. After 2d retailing, the date of sweet cherry with M1, M2, M3 and M4 methods were 0.64%, 0.78%, 3.35% and 5.48%, respectively. Sweet cherry with low temperature significantly \( (P < 0.05) \) inhibited the increase of weight loss compared with other treatments, while no significant difference was found between M1 and M2 \( (P > 0.05) \). M1 was the best method to maintain higher sensory evaluation and reduced the weight loss of sweet cherry among the four retailing methods.

**Respiration Rate and Ethylene Production Rate**

![Figure 2](image2.png)

**Figure 2. Effect of Different Retailed Methods on Respiration Rate and Ethylene Production Rate of Sweet Cherry.**

The respiration rate and ethylene release rate of sweet cherry had the same trend (Fig. 2). The initial respiration rate of sweet cherry was 200.31 mgCO₂·kg⁻¹·h⁻¹ and the ethylene release rate was 0.16 uLkg⁻¹·h⁻¹ after harvest. After forced-air cooling and 3d transportation at 0℃, the respiration rate were 45.73 and 50.84 mgCO₂·kg⁻¹·h⁻¹, respectively, and the ethylene release rate were 0.053 and 0.058 uLkg⁻¹·h⁻¹, respectively. After 2d retailing, the respiration rate of sweet cherry with M1, M2, M3 and M4 methods were 53.89, 80.33, 126.15 and 206.33 mgCO₂·kg⁻¹·h⁻¹, respectively, and the ethylene release rate were 0.063, 0.086, 0.093 and 0.16 uLkg⁻¹·h⁻¹, respectively. The result showed that low temperature treatment significantly \( (P < 0.05) \) inhibited the increase of respiration rate and ethylene release rate of sweet cherry, while no significant difference between M1 and M2
(P > 0.05). M1 was the best method to reduce the respiration rate and ethylene release rate of sweet cherry among the four retailing methods.

**Firmness and Vitamin C Content of Sweet Cherry**

The firmness of sweet cherry after forced-air cooling and 3d transportation at 0°C were 2.93 and 2.87 kg·cm⁻¹, respectively. After 2d retailing, the firmness of sweet cherry with M₁, M₂, M₃ and M₄ methods were 2.83, 2.79, 2.69 and 2.19 kg·cm⁻¹, respectively (Fig. 3(1)). Sweet cherry with low temperature significantly (P < 0.05) maintained higher firmness, and the firmness of sweet cherry had very significant differences between M₁ and M₄ method (P < 0.01). M₁ was the best method to maintain higher firmness among the four retailing methods.

![Figure 3. Effect of Different Retailed Methods on Firmness and Vitamin C Content of Sweet Cherry.](image)

Vitamin C content of sweet cherry after forced-air cooling and 3d transportation at 0°C were 182.09 and 168.87 mg·100g⁻¹, respectively. After 2d retailing, the date of sweet cherry with M₁, M₂, M₃ and M₄ methods were 151.34, 143.88, 108.77 and 83.11 mg·100g⁻¹, respectively (Fig. 3(2)). The result showed that low temperature treatment maintained significantly (P < 0.05) higher levels of vitamin C content. M₁ was the best method to maintain higher vitamin C content of sweet cherry among the four retailing methods.

**TSS and TA Content of Sweet Cherry**

![Figure 4. Effect of Different Retailed Methods on TSS and TA Content of Sweet Cherry.](image)

The TSS and TA content of sweet cherry had the same trend (Fig. 4). After harvest, the initial TSS and TA content of sweet cherry was 22.17% and 0.79%, respectively. After forced-air cooling and 3d transportation at 0°C, the TSS content were 21.83% and 21.4%, respectively, the TA content were 0.79% and 0.75%, respectively. After 2d retailing, the TSS content of sweet cherry with M₁, M₂, M₃ and M₄ methods were 20.4%, 19.9%, 19.6% and 19.1%, respectively, meanwhile, the TA content were 0.7%, 0.68%, 0.67% and 0.59%, respectively. The low temperature treatment delayed the decline of TA and TSS contents and maintained significantly (P < 0.05) higher value in
comparison with other treatments, while no significant difference between M1 and M2 ($P > 0.05$). M1 was the best method to maintain the TSS and TA content of sweet cherry among the four retailing methods.

Conclusions

In the process of cold chain, sweet cherry were packed in plastic clamshell containers within carton, and forced-air cooling rapidly reduced the core temperature of sweet cherry from 27.54°C to 3.1°C in 130min, and transportation and retailing with low temperature maintained the high quality of sweet cherry.

During retailing, the sensory evaluation, weight loss, firmness, respiration rate, ethylene release rate and content of soluble solid, titratable acid, vitamin C were significant affect by temperature among the four different retailing methods and no significant affect between M1 and M2. In the research, the best retailing method of sweet cherry was M1 among the four different methods. Its sensory evaluation, weight loss, firmness, respiration rate, ethylene release rate and content of vitamin C, soluble solid and titratable acid were 8.2, 0.64%, 2.83kg·cm⁻¹, 53.89 mgCO₂·kg⁻¹·h⁻¹, 0.06 uL·kg⁻¹·h⁻¹, 151.34mg·100g⁻¹, 20.4%, 0.7%, respectively.

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References


