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Improving fresh apricot (*Prunus armeniaca* L.) quality and antioxidant capacity by storage at near freezing temperature

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ABSTRACT

Near freezing temperature (NFT) storage was firstly used to improve the quality of fresh apricot. Our results showed that both low-mature and medium-mature apricots could be preserved for 90 d by NFT storage, and still maintained better edible quality and consumer acceptability. Storage at NFT could delay the fruit senescence of apricots by suppressing ethylene production and respiration rate. The soluble solids content of medium-mature apricot stored at NFT was 106.5%, the ascorbic acid was 111.9% and the decay rate was 30.2% of that of apricot stored at 0 °C at the 60th day. In addition, NFT storage enabled apricot to delay the onset of the peak value of phenolic compounds and antioxidant activity, and maintained higher values in the fruit at end of the storage. NFT storage can be considered as a storage technology for improving storage quality and antioxidant capacity of fresh apricot.

1. Introduction

The storage of fresh products at near freezing temperature (NFT) is a preservation technology to maintain low respiration rate and other metabolic reactions. The NFT is a non-freezing temperature range between super-cooling point and biological freezing point of biological material (Shao and Li, 2011; Zhu et al., 2016). It has been proved that the storage at NFT can extend the storage life of fresh foods and provide good quality retention (Jing et al., 2016).

A previous study showed that storage of green beans at NFT could maintain preferable physiological (titrable acids and reducing sugar) and commercial qualities (total soluble solid, weight and skin color) (Guo et al., 2008). Storage of green beans at −0.2 °C could inhibit the pectin degradation and activity of cell wall degrading enzymes (Elfalleh et al., 2015). Sweet corn stored at −1 °C with perforated package can also remarkably prevent weight loss and maintain good sensory attributes (Shao and Li, 2011). However, little is known in literature about fresh fruits storage at NFT.

Since the storage temperature is very close to the biological freezing point of stored fresh plant product, a large temperature fluctuation during NFT storage may lead to freezing injury to the stored product. Therefore a precise and stable temperature environment is the prerequisite to achieve NFT storage of fresh vegetables and fruits.

The present work was aimed to investigate effects of NFT storage on extending storage life and improving quality of fresh apricot. A storage equipment was made to ensure the accurate temperature control (temperature fluctuation less than ± 0.2 °C) for the NFT storage of this study. Our study proved that the quality and antioxidant capacity of fresh apricot could be improved significantly by the storage at NFT.

2. Material and methods

2.1. Preparation of fruit materials

Apricots (*Prunus armeniaca* L. cv. Shushanggan) were collected at two maturities (low maturity and medium maturity) from local orchards in Yining, Xinjiang, China. Low-mature apricots were harvested with firmness of 8.8–12.0 N and soluble solid content (SSC) of 13.7–15.8%, while medium-mature apricots were harvested 10 days later with firmness of 5.4–6.9 N and SSC of 20.9–22.9%. 'Low maturity' represented apricot harvested early with adequate firmness for transport and storage conditions. 'Medium maturity' represented fruit riped adequately for immediate consumption (ready-to-eat). For each maturity, 120 kg similar fruits without physical injuries were picked for uniformity in shape, color, and size, and transferred immediately to the laboratory.

2.2. Determination of apricot NFT and storage equipment

Apricot biological freezing point (BFP) and super-cooling point (SCP) of two mature apricots were respectively determined. Apricot was firstly placed in a −20 °C refrigerator for freeze with temperature

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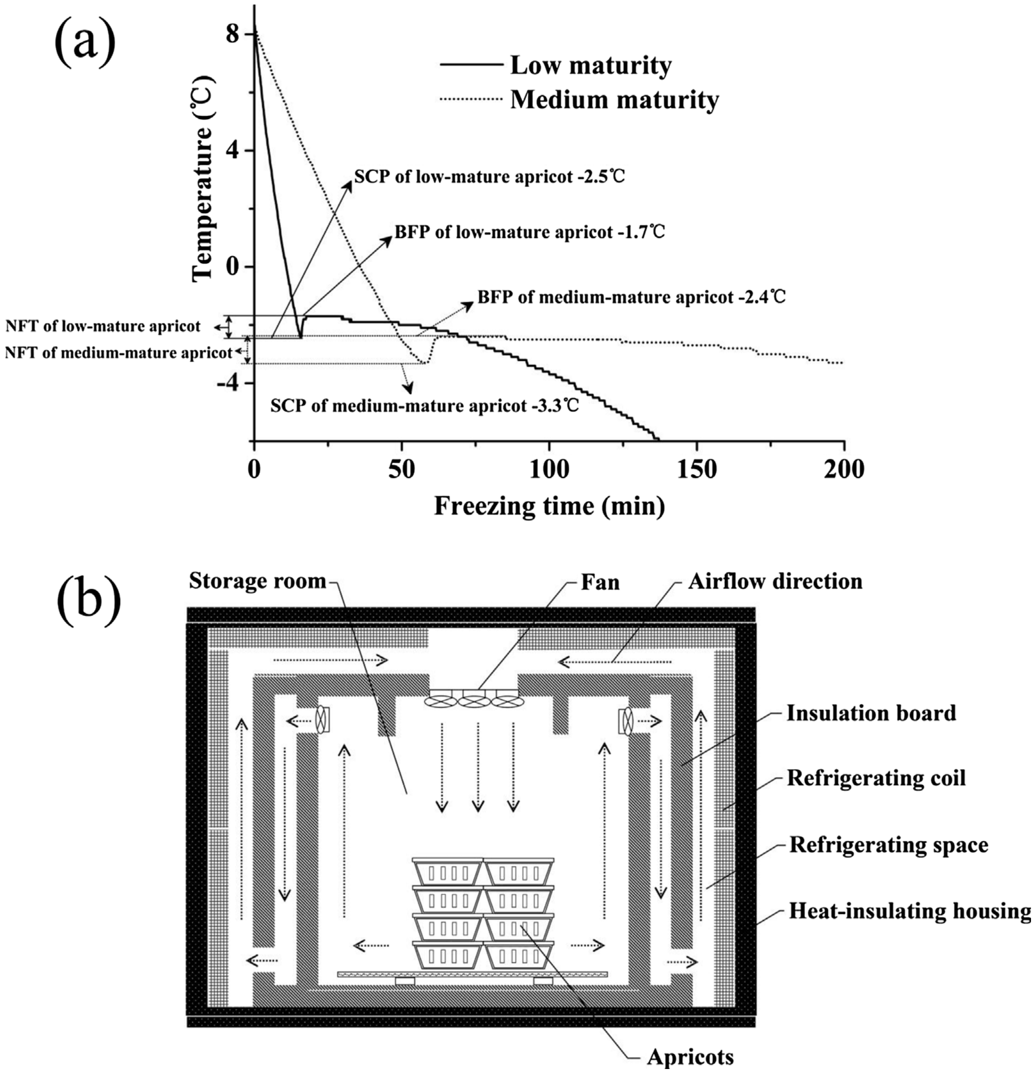

Fig. 1. Simple cooling curve of apricot sample (a) and schematic diagram of NFT (near freezing temperature) storage machine (b).

probe inside the fruit. BFP and SCP were determined based on the cooling curves of apricot samples (Fig. 1a). BFP of low-mature apricot was determined to be −1.7 °C, and SCP was −2.5 °C. So the NFT was −2.5 ~ −1.7 °C, and the storage temperature was set as −2.1 ~ −1.7 °C, which was slightly higher than SCP, to avoid the chilling injury of apricots caused by temperature fluctuation of machine.

A new storage equipment was designed to ensure the temperature of storage room to be stable, and the temperature fluctuation of the new equipment was less than ± 0.2 °C (Fig. 1b). When the machine works, two kinds of temperature control models are performed: refrigerating coil, as traditional refrigerating model, makes refrigerating space a relative lower and larger temperature range of −1.7 ~ −3.5 °C than target temperature (−2.1 ~ −1.7 °C); another model, including fan and insulation board, brings the cold air from refrigerating space into storage room along with airflow direction, which can make storage room a relative precise temperature range to target temperature (−2.1 ~ −1.7 °C). These models also avoid the damage of compressor caused by frequently booting.

For medium-mature apricots, BFP and SCP were determined to be −2.4 °C and −3.3 °C. When medium-mature apricots went into storage, the refrigerating space was set as −2.4 ~ −4.3 °C and the target temperature of NFT storage was −2.8 ~ −2.4 °C.

2.3. Storage conditions

For each maturity, 120 kg apricot fruits were divided into three groups. Each group of 40 kg was placed in plastic baskets and packed with polyethylene bags (thickness: 40 μm). All groups of apricots were pre-cooled in air at 5 °C for 24 h and then stored at 0 °C, 5 °C and NFT, respectively. Physiological attributes of apricot of two maturities were both determined. After storage for 60 d or 90 d, apricots were removed to room temperature (20 °C) for shelf-life quality evaluation. Low-mature apricots were tested to observe the effect of NFT storage on sensory quality, phenolic compounds and antioxidant capacity.

2.4. Measurement of ethylene production and respiration rate

Fifteen apricots representing one replicate were removed to room place to for temperature returning to 20 °C. Apricots were sealed in a 2 L glass container for 2 h at 20 °C. One mL of headspace gas inside the glass container was collected for injection into a gas chromatograph (GC-7890F, Shanghai Techcomp Bio-equipment Ltd, China), which was equipped with a flame ionization detector (FID), a methane conversion oven and a stainless steel column (internal diameter 3 mm × 2 m length) filled with activated alumina (80/100 mesh). Temperature of injector, column and detector was respectively set as 60 °C, 120 °C, 150 °C for ethylene measurement and 60 °C, 120 °C, 360 °C for CO_2 measurement. Ethylene production was calibrated with authentic ethylene gas standards and the results were expressed as $\mu L\ kg^{-1}\ h^{-1}$.