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Hydrocooling rates of Barhee dates at the Khalal stage

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Abstract

The objective of the current study was to determine cooling rates for Barhee dates at the Khalal stage using a batch type hydrocooling technique. Crushed ice mixed with water was circulated within an insulated tank using a 0.5-kW water pump. The temperatures of the ice–water mixture and the dates were monitored and recorded at equal time intervals (1 min). The cooling curves are presented and the half-cooling and seven-eighths cooling times were calculated using linear regression equations fitted for the different size of dates and different initial temperature of the product. The seven-eighths cooling times ranged from 6.18 to 10.23 min. Small sized fruit cooled faster compared to larger ones. However, the difference in size only explained a relatively small fraction of the differences in calculated cooling times. The hydrocooling process with an ice–water mixture was found to be a very effective method to pre-cool dates in order to extend their shelf-life and maintain their quality during distribution.

Keywords: Pre-cooling; Cooling times; Hydrocooling; Dates; Barhee

1. Introduction

Hydrocooling is widely used for rapid cooling of many vegetables as it allows for greater harvesting and marketing flexibility. Produce is exposed to cold water by means of drenching or dipping and the required cooling time is often a matter of minutes. Hydrocooling offers faster and more homogeneous cooling than precooling with air (Golob et al., 2002). One of the main advantages of hydrocooling is that, unlike air pre-cooling, it removes no water from the product and may even revive slightly wilted products (Henry and Bennett, 1973). However, not all kinds of products tolerate hydrocooling.

With hydrocooling, ice-cold water is collected in a reservoir in which the product can be dipped or from which the water can be sprayed or cascaded over the product. The efficiency of the process will depend on the water temperature as well and how well that water makes contact with the surface of product. It should be noted that not all produce is hydro-cooled to 0 °C; tomatoes are sometimes hydro-cooled to 10 °C.

Whole dates of date palm trees (*Phoenix datylifera*) are harvested and marketed at three stages of their development. The three stages are Khalal, Rutab and Tamar. Dates in the Khalal stage are the first in the harvesting season and therefore have a ready market. The best date varieties suitable for marketing at the Khalal stage are Barhee, which are rarely stored. However, for temporary holding, a temperature of 1 °C with a relative humidity of 95–100% is recommended to prevent wilting or drying. To maintain quality and storage life, the fruit should be pre-cooled to 0 °C immediately after harvest to achieve the longest possible storage period (Al-Redhaiman, 2004).

No data are available in the literature concerning the cooling parameters which characterize the performance of Barhee dates during pre-cooling. Therefore, the objective of this work was to determine cooling rates for Barhee dates of different sizes and varying initial temperatures under hydrocooling.

2. Materials and methods

2.1. Materials

The hydrocooling tests were conducted using freshly harvested Barhee dates (*P. datylifera*) obtained from the Qassim area. Fruit were packed in plastic boxes which hold about 10–12 kg. Three sizes of dates were selected to measure pulp temperature. The selected sizes are the most common classes used for sorting and grading Barhee dates in the commercial packhouse. The platform scale method (Mohsenin, 1986) was

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utilized to measure the volumes of the fruit. A digital electronic vernier caliper (Absolute digital, model CD-15CW, Mitutoyo Corporation, Japan) was used to measure the ovoid fruit dimensions, length (*L*) and diameter (*D*). The mass (*M*) was measured with an electronic scale (Mettler-Toledo, model AB204, Mettler-Toledo, Switzerland, 0.1 g accuracy).

2.2. Hydrocooling apparatus

Batch type hydrocoolers are enclosures that do not have conveyors. Product cartons or bulk bins are loaded into the enclosure and put directly under a metal water distributor pan with many holes. The door of the enclosure is then secured, and large amounts of chilled water are distributed over the top of the produce, gathered at the bottom, re-cooled, and redistributed. The product remains stationary through the cooling cycle. At the end of the cooling period, the pump is stopped, the cooled product is replaced by a fresh load of warm product, and the process is restarted.

A batch type drench hydro-cooler was constructed to conduct the experiments as shown in Fig. 1. The outside dimensions were 0.8 m × 0.8 m × 1.5 m. The inner walls were insulated with 50 mm polyurethane at an injected density of 38–40 kg m^{-3}. The outside walls were hot-dipped; 0.6-mm thick galvanized steel sheets, colored white to minimize solar heat absorption. The product chamber was designed to accommodate a box with dimensions of 0.5 m × 0.25 m × 0.22 m. The box could be loaded/unloaded from the cooler and used for repeated runs via a sealed side door. The unit was equipped with a replaceable strainer to filter debris washed from the commodity during drenching. The floor of the water reservoir was 3% sloped to facilitate the drainage process after each trial. Water was pumped through a 50 mm diameter PVC pipe insulated with 10 mm AP Armaflex pipe insulation. The iced water was circulated using a 0.5-kW pump (3450 RPM, 115–230 V, 1-phase, 60 Hz, Model no: GHCX-61SAE, STA-RITE made in USA) powered by an electric motor. Water pressure was regulated using an adjustable pressure relief bypass valve in which the bypass line returned to the reservoir and the pressurized line flowed to the spray nozzle (Tsang and Furutani, in press). The water flow on the fruit surface area was 15.0 L s^{-1} m^{-2} of 1 ± 0.5 °C, which corresponds to the value recommended by Kader (2002) for the hydrocooling of bulk produce. The volume of the water reservoir was 337 L. The distance between the water distribution pan and the top of the product never exceeded 150–200 mm to avoid any water-beating damage. After each treatment, the hydrocooler was drained and fresh tap water (24 ± 1 °C) treated with an active chlorine solution (150 mg L^{-1}) was added prior to the next trial. The water temperature was continuously maintained at 1 ± 0.5 °C through a regular manual supply of crushed ice at a temperature of −10 °C through the side gate. Water temperature was continuously monitored via a temperature probe, with external display, installed inside the water reservoir, as shown in Fig. 1.

The core temperatures for Barhee dates were monitored using Tinytalk data loggers (Model no. TK-4023) equipped with a thermistor probe (PB05005-0M6 Talk Thermistor Probe) (Gemini Data Logger Ltd., UK). The insulated thermistor was inserted longitudinally into the product flesh using a hypodermic needle. The thermistor was sealed with wax at the surface of the product.

To evaluate the efficiency of the hydrocooling process, cooling parameters were also determined for dates air-cooled. The cold storage cooling trials were conducted in a 2 m × 3 m × 2.5 m chamber maintained at 0 ± 1 °C and 90% relative humidity. The average initial temperature of the product was 20 °C. Dates were stored in the same plastic boxes used for hydrocooling.

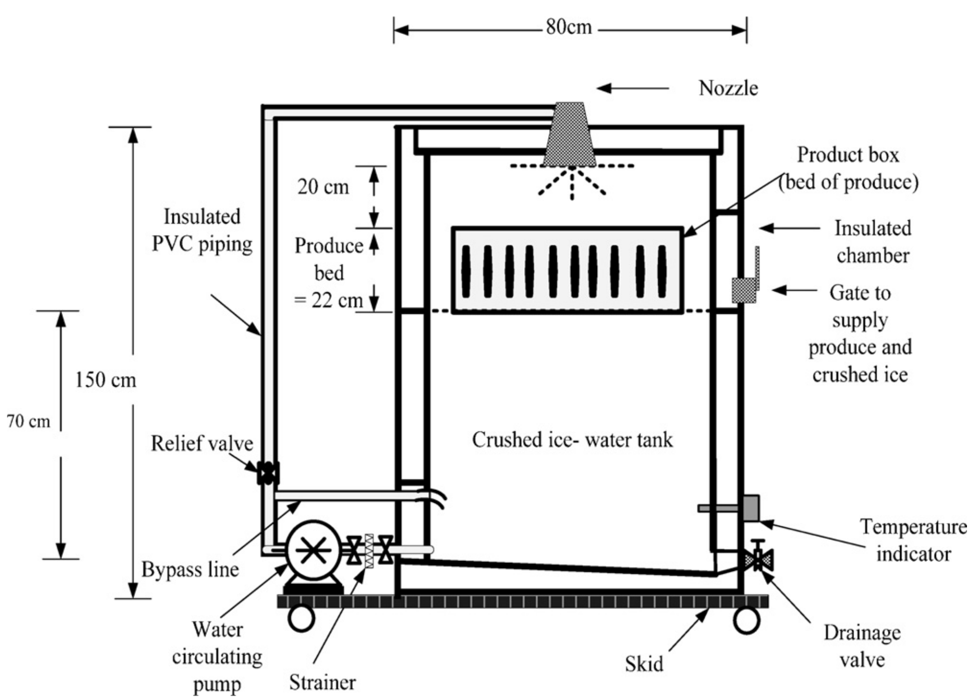

Fig. 1. An illustration of the portable submersion batch type hydrocooler.