Title of Paper: EFFECTS OF FORCED-AIR PRECOOLING ON FRUIT QUALITY AND STORAGE LIFE OF ‘NAMDOKMAI’ MANGO (MANGIFERA INDICA L.)

Authors: Supphaluk Piriaphansakul and Sirichai Kanlayanarat

Address for Correspondence: Dr. Sirichai Kanlayanarat

Division of Postharvest Technology
School of Bioresource and Technology
King Mongkut’s University of Technology Thonburi
Thungru, Bangkok 10140, Thailand
EFFECTS OF FORCED-AIR PRECOOLING ON FRUIT QUALITY AND
STORAGE LIFE OF ‘NAMDOKMAI’ MANGO (MANGIFERA INDICA L.)

ABSTRACT

Mango fruit cv. ‘Namdokmai’ (Mangifera indica L.) harvested at the mature-green stage were precooled by forced air cooling (1-2 m/s air velocity) at 5°C, 8°C, 10°C or 13°C. Fruit temperature expectedly decreased from an initial level of about 28-32°C to the desired storage temperature of 13°C at the most rapid rate at 5°C, for about 30 min. Cooling time increased to 80, 110 and 155 min when precooling temperature increased to 8°C, 10°C, and 13°C, respectively. During subsequent storage at 13°C with 90-95% relative humidity, precooled fruits did not exhibit more desirable characteristics than that of non-precooled fruits (control). Although peel and pulp yellowing was slightly delayed as shown by reduced rates of $b^*$ increase, precooling did not retard softening. Both precooled fruits and the control turned ripe-soft after 15 days when firmness decreased to less than 10 N from about 70N at the unripe stage. Similarly, precooling did not reduce weight loss, respiration and ethylene production rates. Precooling at 10-13°C even resulted to much higher weight loss than the control after 10-20 days of storage.

Key words: Mango; Mangifera indica L. cv. ‘Namdokmai’; precooling; forced air cooling; cold storage; ripening; postharvest life
INTRODUCTION

Mango (*Mangifera indica* L.) is a major tropical fruit in the domestic and export markets of Thailand. ‘Namdokmai’ is the most popular variety with production ranking first among commercial mango varieties. The fruits are usually harvested mature-green, about 91-105 days from full bloom and with a starch content of about 18-20% (Tungtirmthong, 1998). After harvest, ripening rapidly sets in and the fruit could become full ripe in 4-5 days at ambient (Yantarasri et al., 1994). At the ripe stage, diseases particularly stem-end rot and anthracnose usually develop. The high perishability of mangoes is an important constraining factor in production, distribution and marketing, which must be adequately addressed to expand production and marketing options, improve market competitiveness, and ensure a sustained increase in domestic and international trade. This is made more relevant by the increased competition in the world market brought about by the initiatives for global trade liberalization and trade barrier dissepation.

Among postharvest conditions that have influence on quality and longevity of fresh produce, temperature has the greatest effect. At high temperatures, respiratory activity is increased, which can lead to the depletion of food reserves and acceleration of ripening and senescence. It has been estimated that for each 10°C rise in temperature within the physiological range, respiration rate increases by two to three fold. Thus, to retard ripening and increase storage life of the fruit, proper temperature management during handling and storage is essential. The importance of temperature management in maintaining the quality of fresh fruits and vegetable is well recognized (Kader, 1992). A temperature of 13°C is generally recommended in the cold storage of mango (Tungtirmthong, 1998). Lower temperatures could result to chilling injury while higher temperatures increase metabolic activity in the fruit, both of which would correspondingly reduce storage life. Because of the beneficial effects of low storage temperatures in extending storage life, rapid attainment of
such temperature is expected to always have a positive effect on produce quality. Fruit temperature at harvest could be as high as 35°C and lowering this to recommended level as quickly as possible could be a decisive initial step in storage management (Joyce and Patterson, 1994). Precooling or the rapid removal of field heat immediately after harvest of the fruit not only reduces refrigeration load but also preserves product quality and increases the shelf life by restricting enzymatic and respiratory activity, reducing ethylene production, slowing the rate of water loss, and inhibiting the growth of decay-causing microorganisms (Hardenburg et al., 1986). Precooling has been shown to reduce weight loss, retard surface color changes, and improve shelf life of a number of fresh produce (Osman and Mustaffa, 1994; Gillies and Toivonen, 1995; Sullivan et al., 1996).

Forced-air cooling is one of the most efficient precooling methods (Sullivan et al., 1996). This was demonstrated in muskmelon in which lowering the internal pulp temperature from 35°C to 5.5°C by forced-air cooling resulted to the maintenance of the highest level of market quality of the fruits relative to the other precooling methods. Forced-air cooling has also been used in strawberry and was demonstrated to be a very important treatment prior to cold storage for the maintenance of acceptable appearance, texture and nutritive value of the fruits (Nunes et al., 1995a, 1995b).

In this study, forced-air cooling was tested using different temperature regimes, determining their relative efficacy in bringing down fruit temperature to recommended level for cold storage and in maintaining quality and extending shelf life of ‘Namokmai’ mango during subsequent low temperature storage.
MATERIALS AND METHODS

Experimental Treatments

Freshly harvested, fully mature-green ‘Nam dok mai’ fruits were procured from a commercial orchard and selected for uniformity in size and shape, each weighing about 350 grams, and freedom from defects. Forced air cooling was done in a refrigerated room at 5°C, 8°C, 10°C or 13°C with air velocity of 1-2 m/s. During cooling, five sample fruits were penetrated with thermocouple for temperature monitoring. Treatment was terminated when pulp temperature reached 13°C. The fruits were then stored at 13°C with 90-95% RH. Fruits not forced air-precooled served as control. The study was done following procedures for completely randomized design experiments. Four replications were used, with each replication having 6 fruits per observation period. Observation of fruit responses was done at 5-day interval.

Measurement of Fruit Responses

Color change. Changes in peel and pulp color were determined using a Minolta DP-301 colorimeter. The b* readings (positive values) were taken as a measure of degree of yellowing while the L* value, as a measure of changes in surface lightness.

Firmness and weight loss. Firmness was measured using TA-TX2 texture analyzer equipped with a 500 kg load cell and 2mm-diameter plunger set to pierce 5 mm deep from the fruit surface. Cross head and chart speed were 100 mm/min and 300 mm/min, respectively.

The weights of the fruits were taken at each observation period and cumulative weight loss was calculated as percentage of the initial weight.

Respiration and ethylene production. Respiration and ethylene production were determined by gas chromatography. Three fruits were sealed in a respiration jar for 3 hours at 20°C. One ml gas samples were taken using gas-tight hypodermic syringe and injected
into the Shimadzu GC-8A gas chromatograph with thermal conductivity detector and molecular sieve 5A column at 50°C for CO₂ analysis and Shimadzu GC-14B with flame ionization detector and Porapak Q column at 50°C for ethylene analysis.

Results were subjected to analysis of variance (ANOVA) using the general linear models procedure by SAS (SAS Institute, Cary, N.C.) for completely randomized design experiments and Duncan’s multiple range test (DMRT) or Least Significance Difference (LSD) test for treatment mean comparison.

RESULTS

Figure 1 indicates the rate of decrease in pulp temperature during forced air cooling at 5-13°C. Bringing down the fruit temperature from about 28-32°C to the desired storage temperature of 13°C was expectedly fastest at 5°C and slowest at 13°C. It took about 30 min for the pulp temperature to drop to 13°C at 5°C and about 155 min or 2 hours and 35 min at 13°C. At 8°C and 10°C, the time spent to reduce the pulp temperature to 13°C was about 80 and 110 min, respectively.

During subsequent 13°C storage, forced air-precooled fruits did not exhibit desirable characteristics indicative of more favorable treatment effects for quality maintenance and shelf life extension. There was an indication of ripening delay induced by the precooling treatment. Yellowing of the peel and pulp based on increases in b* values proceeded at a relatively reduced rates in precooled fruits than in non-precooled ones (control) (Figure 2). This was noted after 15-20 days of storage, with the 5-10°C precooling treatment causing consistently lower b* values and hence reduced rate of yellowing of both peel and pulp.

Changes in L* values did not reflect the increasing degree of yellowing with ripening of the fruit (Figure 2). However, in terms of softening, precooling had no delaying effect. Firmness decrease as a measure of softening was even faster in fruits precooled at 8-13°C while that of
fruits precooled at 5°C had similar rate of firmness loss as the control (Figure 3A). In addition, all fruits, precooled or not, turned ripe-soft after 15 days of storage when firmness decreased to less than 10N from an initial level of about 70N of unripe fruits at the start of storage.

Weight loss was likewise not reduced by forced air cooling (Figure 3B). Fruits precooled at 10-13°C had even much higher weight loss than the control after 10-20 days of storage. The other forced air cooling treatments using lower temperatures of 5-8°C resulted to weight loss comparable to that of non-precooled fruits. Similarly, forced air cooling had no significant influence on physiological changes measured as rates of respiration and ethylene production (Figure 4). Respiration increased with storage, generally reached peak levels after 10 days of storage, and remained at elevated levels up to the end of the storage period. On the other hand, ethylene production did not greatly differ with treatment during the first 15 days of storage. Five days later, ethylene production of fruits precooled at 8-13°C dramatically increased while that of the control (?) and those precooled at 5°C remained at levels comparable to the previous rates of ethylene production. The results seemed to manifest further the insignificant influence of forced air cooling on ripening retardation, quality retention and shelf life extension of the fruits.

**CONCLUSION**

Forced air cooling could rapidly remove field heat from the fruit which is necessary to reduce refrigeration load during subsequent cold storage at 13°C. However, it seems to have no beneficial effect on fruit quality and shelf life. In certain cases, it may result to undesirable storage behavior such as the increased in weight loss when fruits were forced air-precooled at higher temperatures of 10-13°C.
LITERATURE CITED


Figure 1. Changes in pulp temperature of ‘Namdokmai’ mango during force air cooling at 5-13 °C
Figure 2 Peel and pulp L* and b* of ‘Namdokmai’ mango during storage at 13 °C as affected by forced air cooling at 5-13 °C
Figure 3. Firmness and weight loss of ‘Namdokmai’ mango during storage at 13 °C as affected by force air cooling at 5-13 °C.
Figure 4. Respiration and ethylene production rate of ‘Nam dok mai’ mango during storage at 13°C as affected by forced air cooling at 5-13°C.