College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

Fruits , Nuts, and Beverage Crops
September 2014
F_N-43

Mango: Postharvest Quality-Maintenance Guidelines

Robert E. Paull and Ching Cheng Chen
Department of Tropical Plant and Soil Sciences

Mango is cultivated throughout the tropics and warmer sub-tropics (Narayana et al. 2012). There are numerous varieties, with the Florida varieties 'Tommy Atkins', 'Kent', 'Keitt', and 'Hayden' being the most common in the U.S. Fruit skin is yellow or green with a golden to red blush. Weight can vary from 200 g to 1 kg (0.5 to 1 lb), and the fruit can be round, oval, or kidney shaped. Some varieties have a turpentine-like smell and taste. Paull and Duarte 2011, Narayana et al. 2012)

Mango, *Mangifera indica* L.

Quality Characteristics and Criteria

Skin coloration, size, shape for variety, appearance, freedom from defects and decay, absence of fiber in the flesh, and absence of turpentine-like flavors are the most common quality parameters. Wilted, grayish discoloration and pitting are undesirable. Some fruit varieties such as 'Hayden' have pinhead-size black spotting that is not regarded as a defect.

Horticultural Maturity Indices

The general measures of maturity for most cultivars of mango are when the fruit "shoulders" have risen above the stem-end and there is a slight skin color break on the first fruit of a crop. Early fruit from a single flowering should only be harvested after a slight skin color change; 2 weeks later all full-size fruit can be harvested, even if there is no apparent skin color change. Other indices include soluble solids content (SSC) and titratable acidity (TA), fruit specific gravity, days from blooming, and the natural abscission of the first few fruits. These indices need to be adjusted for cultivar and season (Hatton et al. 1965, Kanes et al. 1982, Narayana et al. 2012). Harvested immature fruit have poor quality, flavor, and sugars and fail to ripen evenly.

Grades, Sizes, and Packaging

The U.S. and International Grade standards give general information on the desirable characteristics of the fruit and tolerance in packing for defects and disease. Color is green-yellow to red blush, depending upon variety. Fruit are sold in 16 kg (35 lb) cartons as well as 6 kg (14 lb) flat single-layer cartons and 4.5 kg (10 lb) single-piece fiberboard boxes with various counts.

Pre-Cooling Conditions

Fruit are normally forced-air or room-cooled, preferably within 24 h of harvest (Mattern et al. 1972).

Published by the College of Tropical Agriculture and Human Resources (CTAHR) and issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, under the Director/Dean, Cooperative Extension Service/CTAHR, University of Hawai'i at Mānoa, Honolulu, Hawai'i 96822.

Optimum Storage Conditions

Storage at 10 to 13°C (50 to 55°F) with 85 to 90% relative humidity should give a shelf-life of 14 to 28 days for mature green fruit, depending upon variety. Ripe fruit can be stored at 7 to 8°C (44.6 to 46.4°F). Diseases are the principal factor limiting storage-life. Optimum ripening temperature is 20 to 23°C (68.0 to 73.4°F) for best appearance, palatability, and decay control (Jobin-Decor 1988).

Controlled Atmospheres (CA) Considerations

Different cultivars show various responses to CA. The optimum storage atmospheres for prolonging storage and/or shipping are 3 to 6% O_2 + 3 to 10% CO_2 at 7 to 9°C (44.6 to 48.2°F) with 90% relative humidity (Yahia 1998). Ripening delays are minor and may not be economic in all situations. Polyethylene or other film bags with and without an ethylene absorber give some delay in ripening. However, some bags lead to off-flavor and abnormal skin coloration.

Retail Outlet Display Considerations

Display at store temperature, do not mist. Discard bruised and diseased fruit from display.

Chilling Sensitivity

Chilling susceptibility varies with cultivar; 'Hayden' and 'Keitt' are particularly susceptible. Most cultivars show injury below 10°C (50°F), especially if fruit have just reached maturity. Tolerance to chilling increases during ripening (Medlicott et al. 1990). The symptoms include grayish, scald-like discoloration on the skin, followed by pitting, uneven ripening, and poor flavor and color development (Hatton et al. 1965, Medlicott et al. 1990). Heat treatment prior to storage reduces injury in 'Keitt' (McCollum et al. 1993).

Mango affected by jelly seed.

Ethylene Production and Sensitivity

Mangoes have moderate ethylene production of 1 to 2 µL kg^{-1} h^{-1} at 20°C (68°F). Ethylene induces faster and more uniform softening (Lakshminarayana 1973, Barmore 1974). Ethylene treatment can be done prior to shipping (Barmore and Mitchell 1977). There is disagreement in the literature regarding the effect of ethylene treatment on quality (Chaplin 1988). This may relate to the fruit's maturity when treated. Treatment of immature fruit leads to softening, but the fruit have poor flavor. A treatment with methylcyclopropene (1-MCP) at 100 to 250 ppb for 12 to 24 hours delays ripening and softening, extends postharvest life, and can reduce some chilling injury symptoms (Jiang and Joyce 2000, Hofman et al. 2001).

Respiration Rate

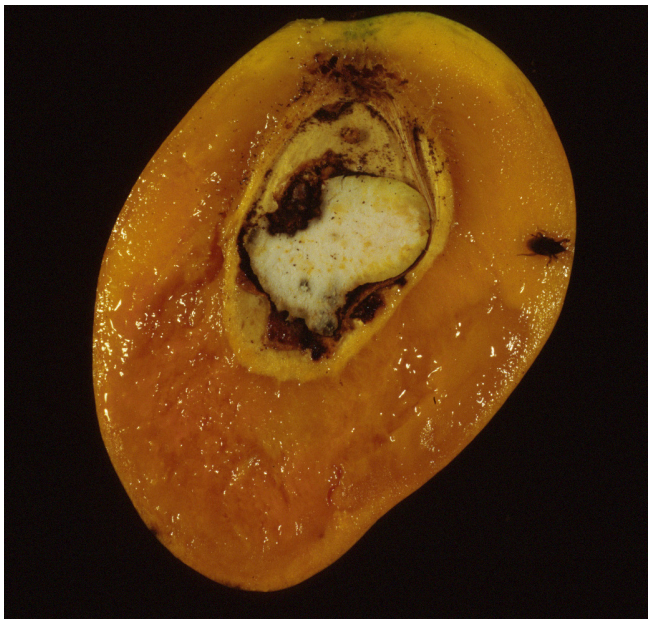
To get mL and kg^{-1} h^{-1}, divide the mg kg^{-1} h^{-1} rate by 2.0 at 0°C (32°F), 1.9 at 10°C (50°F), and 1.8 at 20°C (68°F). To calculate heat production, multiply mg kg^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day. Data are from Karmarkar and Joshi (1941) and Lam (1987).

Heating for insect disinfestation elevates respiration 3- to 5-fold; after cooling, rates remain higher than those of unheated fruit for 4 to 6 days (Mitcham and McDonald 1993).

Table 1. Respiration Rates

Temperature	mg CO_2/$kg^{-1}h^{-1}$
4.5 °C	10 to 22
10 °C	23 to 46
15 °C	45 to 90
20 °C	75 to 151

Mango with sap damage.



Mango weevil and fruit fly damage.

Physiological Disorders

Some disorders, such as chilling injury and high CO_2 injury, are induced after harvest, while others are inherent. Inherent disorders occur intermittently and are unpredictable, such as jelly seed, which results in watery, translucent tissue around the seed, giving an over-ripe appearance. It does not develop after harvest unless it was present at harvest (Young and Miner 1961). Some cultivars are very susceptible, such as 'Tommy Atkins' (Lelyveld and Smith 1979). Soft nose and internal breakdown (or spongy tissue) are other disorders (Lim and Khoo 1985), though it is possible these are one and the same. Sap burn is a major problem with some cultivars (O'Hare 1994), such as 'Kensington', while 'Irvin' is less susceptible (Loney et al. 1992). Washing with water and detergent helps to avoid damage (Brown et al. 1986).

Postharvest Pathology

Anthracnose (*Colletotrichum gloesporioides*), which is due to pre-harvest infection and does not spread postharvest, and the postharvest stem end rots caused by several fungi that infect before and after harvest (often as wound invaders that spread postharvest), are the two most common diseases (Johnson and Coates 1993). Anthracnose develops as fruit ripen, first appearing as superficial black spots and streaks that then become sunken (Fitzell and Peak 1984).

Alternaria rot (*Alternaria alternata*), a pre-harvest infection, can sometimes be a problem, while postharvest wound infections such as Black Mold (*Aspergillus* spp.) and transit rot (*Rhizopus* spp) can occasionally be severe. Disease control begins in the field, followed by postharvest sanitation, avoidance of latex burn (stain), and mechanical injury. Hot water treatment (46°C for 60 to 120 minutes) and fungicides can be used, depending on cultivar (Spalding and Reeder 1986). Hot water brushing at 55°C (131°F) for 20 seconds shows good control (Prusky et al. 1999).

Quarantine Issues

As a fruit fly host, mango must be treated prior to import into the U.S. Hot water at 46.5°C (116°F) for 65 to 90 min and vapor heat with fruit core temperature of 46 to 48°C (115 to 118°F). Irradiation at 165 Grays is approved by APHIS for fruit fly and mango seed weevil.

Suitability as Fresh-Cut Product

Fresh-cut pieces and slices are frequently found in markets. Flesh browning can be a problem in some cases.

Special Considerations

None

An earlier version of this article was originally published at the USDA website: www.ba.ars.usda.gov/hb66/contents.html

References

Barmore, C.R. 1974. Ripening mangoes with ethylene and ethephon. *Proc. Florida St. Hort. Soc.* 87:331–334.

Barmore, C.R. and E.F. Mitchell. 1977. Ethylene preripening of mangoes prior to shipment. *The Citrus Industry* 58:18–19, 22–23.

Brown, B.I., I.A. Wells and C.F. Murray. 1986. Factors affecting the incidence and severity of mango sap-burn and its control. *ASEAN Food J.* 2:127–132.

Chaplin, G.R. 1988. Advances in postharvest physiology of mango. *Acta Hort.* 231:639–648.

Fitzell, R.D. and C.M. Peak. 1984. The epidemiology of anthracnose disease of mango: inoculum sources, spore production and disposal. *Ann. Appl. Biol.* 104:53–59.

Hatton, T.T. Jr., W.F. Reeder, and C.W. Campbell. 1965. Ripening and storage of Florida mangos. *USDA Market Res. Rpt.* No. 725, Washington, DC, 9 pp.

Hofman, P.J., M. Jobin Décor, G.F. Meiburg, A.J. Macnish, and D.C. Joyce. 2001. Ripening and quality responses of avocado, custard apple, mango and papaya fruit to 1–methylcyclopropene. *Australian Journal of Experimental Agriculture* 41, 567–572.

Jiang, Y., D.C. Joyce. 2000. Effects of 1-methylcyclopropene alone and in combination with polyethylene bags on the postharvest life of mango fruit. *Annals of Applied Biology*, 137(3), 321–327.

Jobin-Decor, M.P. 1988. Mango ripening guide. *Queensland Agric. J.* 114:369–371.

Johnson, G.I. and L.M. Coates. 1993. Postharvest diseases of mango. *Postharv. News Info.* 4:27n-34n.

Kanes, O., M. Boulet, and F. Costaigne. 1982. Effect of chilling-injury on texture and fungal rot of mangoes (*Mangifera indica* L.). *J. Food Sci.* 47:992–995.

Karmarkar, D.V. and B.M. Joshi. 1941. Respiration studies of the alphonse mango. *Ind. J. Agric. Sci.* 11:993–1005.

Lakshminarayana, S. 1973. Respiration and ripening patterns in the life cycle of the mango fruit. *J. Hort. Sci.* 48:227-233.

Lelyveld, L.J. van and J.H.E. Smith. 1979. Physiological factors in the maturation and ripening of mango (*Mangifera indica* L.) fruit in relation to the jelly seed physiological disorder. *J. Hort. Sci.* 54:283–287.

Lam, P.F. 1987. Respiration rates and ethylene production of ripening Harumanis mangoes after different chilling storage periods. *MARDI Res. Bull.* 95:15–19.

Lim, T.K. and K.C. Khoo. 1985. *Diseases and disorders of mango in Malaysia*. Kuala Lumpur, Trop. Press., 101 pp.

Loney, B.R., S.P. Robinson, J.J. Brophy, and E.K. Chacko. 1992. Mango sap-burn, components of the fruit sap and their role in causing skin damage. *Austral. J. Plant Physiol.* 19:449–457.

Mattern, F., W. Pennock and L.S. Valles. 1972. Supplying the New York market with high quality Puerto Rican mangoes. *J. Agric. Univ. Puerto Rico* 56:1–10.

McCollum, T.G., S. D'Aquino, and R.E. McDonald. 1993. Heat treatment inhibits mango chilling injury. *HortScience* 28:197–198.

Medlicott, A.P., J.M.M. Signist, and O. Sy. 1990. Ripening of mangoes following low temperature storage. *J. Amer. Soc. Hort. Sci.* 115:430–434.

Mitcham, E.T. and R.E. McDonald. 1993. Respiration rate, internal atmosphere and ethanol and acetaldehyde accumulation in heat-treated mango fruit. *Postharv. Biol. Technol.* 3:77–86.

Narayana, C.K., D.S. Rao, and S.K. Roy. 2012. Mango production, postharvest physiology and storage. pp. 259-276. In: M. Siddiq (ed). *Tropical and subtropical fruits: Postharvest physiology, processing and packaging.* John Wiley: Oxford, UK.

O'Hare, T.J. 1994. The susceptibility of Thai and Australian mango cultivars to sap injury and possible means of control. In: G.I. Johnson and E. Highley (eds) *Development of Postharvest Handling Technology for Tropical Tree Fruits. ACIAR Proc.* No. 58, Canberra, Australia, pp. 21–24.

Paull, R.E. and O. Duarte. 2011. Chapter 10: Mango. pp. 252–290. In: *Tropical fruit - Volume I.* CAB International, Wallingford, UK.

Prusky, D., Y. Fuchs, I. Kobiler, I. Roth, A. Weksler, Y. Shalom, E. Fallik, G. Zauberman, E. Pesis, M. Akerman, O. Yekutiely, A. Weisblum, R. Rogev, and L. Artes. 1999. Effects of hot water brushing, prochloraz treatment and waxing on the incidence of black spot decay caused by Alternaria alternata on mango fruits. *Postharv. Biol. Technol.* 15:165–174.

Spalding, D.H. and W.F. Reeder. 1986. Decay and acceptability of mangoes treated with combination of hot water, imazalil and γ-radiation. *Plant Dis.* 70:1149–1150.

Yahia, E.M. 1998. Modified and controlled atmospheres for tropical fruits. *Hort. Rev.* 22:123–183.

Young, T.W. and J.T. Miner. 1961. Relationship of nitrogen and calcium to 'soft-nose' disorder in mango fruits. *J. Amer. Soc. Hort. Sci.* 78:201–208.