



Improving Harvest and Postharvest Practices on 'Mallika' Mango for the Local Industry

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From the tree to the consumer's plate, every step in the mango supply chain presents an opportunity to improve quality. Mango harvest criteria can vary with local consumption patterns and distance to market. In practice, the total harvest period is very short and the grower has very little time in which to make correct decisions. For this study, 'Mallika' fruit was evaluated from picking to final destination. The study was conducted using a mango crop marketed directly by the grower and the fruit was shipped to the northern market in the United States. Indian cultivars were not selected for a postharvest cold chain as exposure of the fruit to standard shipping temperatures and techniques can result in loss of quality. This study provides a clear understanding of how fruit quality can be improved in 'Mallika' mangos for the local market. This study includes production, harvest, postharvest, and handling practices from maturity assessment to packaging solutions and interstate shipping alternatives.

Air shipments of Indian mangos to the United States began in 2006. Cultivars such as 'Alphonso', 'Kesar', and 'Totapuri' are being flown to the United States for a select clientele who service the ethnic Indian community in the United States. (Campbell and Ledesma. 2013).

India has grown mangoes for thousands of years, and produces the majority of the world's mango crop. They have lot of challenges in infrastructure—protocols, pest quarantines, and the sheer distance limit exports to the United States. The U.S. Department of Agriculture allowed the importation of Indian-grown mangos treated with irradiation to kill or sterilize insects. This is still a controversial issue. In addition, quality issues have been an obstacle to the importation associated with irradiation treatment and with the inherent nature of the cultivars and postharvest handling of the product.

Reported prices of Indian mangos are still high, generating considerable interest among western growers. There is particular interest of Indian cultivars in South Florida, such as 'Alphonso', 'Kesar', and 'Mallika'. Indian mangos are known for their exceptional flavor, pulp color, and sugar content. Production and postharvest programs in the Western Hemisphere are often not compatible with these cultivars. Grower expectations must be adjusted. In the hot tropics, Indian cultivars such as 'Alphonso' have many problems with natural and induced flowering. 'Mallika' is one of the Indian cultivars which performs well in South Florida. It is highly disease resistance, and has good yields.

(Campbell and Ledesma. 2006). Local growers in South Florida must be aware of the challenges involved with the production of Indian mango cultivars to fully realize the desired benefits.

Postharvest handling techniques have been developed over the centuries in India for local cultivars. Traditionally, Indian mangos have been stored at high temperatures than can reach between 90 to 100 °F. For centuries Indian growers developed their own ripening systems. Mangos are picked when they still green and unwashed and are kept with the natural waxy skin. Mangos are packed in wooden boxes filled with natural grass. Mangos are stored in dark, ventilated structures which can reach up to 100 °F during the day. The mangos will ripen with an intense aroma (bouquet) and perfect sweetness in 8–10 days. Some farmers just lay fruit down on a concrete surface in a dark room and cover the fruit with fabric.

The modern mango industry continues to adapt to changes in consumer demands for fresh mangos and mango products. Producers in the United States are increasingly interested in alternative mango cultivars for the fresh and processed markets. Current Western Hemisphere harvesting and postharvest handling practices must be modified for these cultivars to produce the desired fruit quality. Indian cultivars were not selected for a postharvest cold chain and exposure of the fruit to standard export temperatures and techniques can result in loss of quality. Growers in the Western Hemisphere should be aware of the challenges involved with the production of Indian mango cultivars to fully realize the desired benefits. Therefore, it is necessary to develop improved methods of mango storage to enhance shelf life without any detrimental effects on quality.

Materials and Methods

The study was conducted in a private mango farm in the Redland farming district of Miami-Dade County in South Florida. The orchard consists of a 1.5-acre planting. Tree spacing is 6 m

For their help in contributing in this project tasting the 'Mallika' mangos at the final destination, the author is profoundly grateful to Maricel E. Presilla, chef, restaurateur, and a recognized authority on mangos and Baskar Savani, whose family grows mangoes in Gujarat, and who imports Indian mangos to the United States. They both cared for the mangos for over three weeks and carefully evaluated the fruit and provided information for this experiment.

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between the rows and 4 m within the row. Trees were not irrigated and no additional inputs of fertilizer or pesticides were used. Ground covers are used to suppress weeds. Mowing and hand weeding were performed as needed.

'Mallika' is a hybrid between 'Neelum' and 'Dusheri'. 'Mallika' is considered among the best of the new generation of Indian dessert mangos (Campbell and Ledesma, 2004). The tree is semi-dwarf, making it attractive to mango growers outside of India, who are always looking for new niche markets. The bright yellow fruit has a flattened oblong shape, with a rounded base and an irregular, non-waxy skin. Fruit weigh between 10–18 oz. When properly ripened, the pasty, but completely fiber-free flesh is a deep orange, with an intensely sweet, rich and highly aromatic flavor (Ledesma, 2015).

The grower does his own marketing, with fruit shipped to markets in the northern states of the United States. The fruit was harvested, washed, and packed, using the protocols as follow::

PICKING. Harvesting was done by hand. Fruit was picked using clippers, leaving a 20 mm stem attached to protect the fruit from sap burn. The fruit was placed into field crates or bins. Harvest was done using multiple pickings since fruit do not ripen all at the same time.

Fruit were harvested at the 70% to 80% maturity stage. Accurately, estimating when the fruit is ripe is critical to consistently meet customer expectations. It relies on visual observations and is also calendar based. Mangos normally reach maturity in 4 to 5 months from flowering. 'Mallika' fruit was harvested from June to July. The fruit was picked with a light green skin color and a range weight from 300 to 450 g. The fruit develops an oblong sigmoid shape the shoulders fill when mature.

Fruit was moved to a facility for cleaning and packing. Fruit was unloaded from field bins after being washed.

PACKING AND RIPENING. There are no USDA grade standards for mango and they are sorely needed. Sugar content, acid content, color test, specific gravity of the fruit, and time of blooming are some of the criteria used to determine fruit maturity. Fruit were sorted by weight into three categories shown in Table 1.

Keeping fruit separated by size, the fruit was stored at an average of 70 °F night and 93 °F daytime temperatures; it was never cooled. The fruit was evaluated every week to measure brix and internal color to pack and ship (Table 2).

Table 1. Size categories of treatment fruit by weight (g).

Small fruit	Medium fruit	Large fruit
< 310	310–380	> 380

Table 2. Average fruit rating before shipping.

Evaluation day	T1 (small) ^z			T2 (medium) ^y			T3 (large) ^x		
	Weight (g)	Brix	Internal color	Weight (g)	Brix	Internal color	Weight (g)	Brix	Internal color
1	300	13	cream	340	14.5	cream	370	15.00	cream
5	299	14	Pale yellow	339	15.5	Pale yellow	370	15.00	Pale yellow
6	299	15	Pale yellow	339	16.5	Pale yellow	369	15.00	Pale yellow
7	299	16	Pale yellow	339	16.5	Pale yellow	365	16.00	Pale yellow
8	298	17.5	yellow	339	17.5	orange	360	17.00	yellow
9	299	18	orange	338	18.5	orange	356	17.5	orange
10	298	18	orange	338	18.5	orange	350	18.5	orange

^zSmall: 250 g average.

^yMedium: 310 g average.

^xLarge: 300 g average.

Table 3. Average fruit rating on arrival.^z

Evaluation Day	T1 (Small)	T2 (Medium)	T3 (Large)
14	2 ^y	2	2
16	2	1	1
18	2	1	1
20	1	1	1
22	1	1	3
24	1	1	3

^zPhysical appearance at arrival 14 days after picking.

^yScores: 1 = good (ready to eat); 2 = acceptable (not ripe); and 3 = not acceptable (over ripe).

The fruit was packed manually into single-layer cardboard boxes by size (Table 1). Organic material (paper) was used to cushion each fruit in the boxes. There is no box made especially for mangos. However, local growers are using existing boxes available in the market. For this experiment, flat rate U.S. Post Office (USPS) Priority Mail Medium Flat Rate (11" × 8.5" × 5.5") and Priority Mail Large Flat Rate (12" × 12" × 5.5") boxes were used.

The final destinations were two customers in Weehawken, NJ, and Maple Glen, PA. Five boxes of each treatment (Table 1) were shipped to the two customers. The shipping time to the destinations was 3 days. We used two mango experts to evaluate the fruit on arrival. Quality at destination was evaluated based in sugar content and overall appearance of the fruit (Table 3).

STORAGE AND TEMPERATURE. Table 2 shows fruit size, weight, internal color, external color, and brix before shipping. We sent 10 boxes per size category (Table 1) to Weehawken, NJ, and Maple Glen, PA. Mango experts evaluated at the fruit on arrival, with results shown in Table 3. The evaluations at the destination continued weekly until fruit were considered "Good" or "Ready to eat". The fruit was never stored below 70 °F. Specifications on the box recommend keeping fruit in the box and holding it at room temperature or outside.

Temperature is a very important factor that influences fruit maturity and quality of the fruit. Indian cultivars were not selected for a postharvest cold chain so exposure of the fruit to standard export temperatures can result in loss of quality. Using air shipments, it takes 2–3 days to reach a destination in the northern U.S. Our plan is to develop a protocol that allow fruit to arrive at final destination ready to eat.

Results and Discussion

FRUIT WEIGHT. The fruits were graded while they were green, and packed while they are still green or semi-ripe. The weight

decreased by the time the fruits were ripe, during transit and also due to moisture loss if the weather is dry. There is no set formula to predict weight loss. The way the grading is done commercially, using a specially calibrated weighing machine shows the grade of each mango, which then goes into a dedicated baskets. For our experiment we used commercial standards as a reference.

'Mallika' fruit range between 250–420 g. Fruit is normally sold by the piece and in some cases by weight. Large fruit can be less attractive for the growers because the profits can be lower. It is advantageous for growers to be able to identify smaller fruit that can ripen properly.

FRUIT APPEARANCE. External color, appearance, and pulp color are indicators for judging the fruit maturity. At the time of maturity for 'Mallika', the pit becomes hard and pulp color changes from white or cream and finally yellow or orange (Table 2). The flesh color changes with fruit maturity, and grades A1, A2, and A3 ripen in 14–24 days from harvest (Table 3).

Observations show that the skin of 'Mallika' is smooth and uniform, although at ripening the fruit may shrivel slightly. By the time ripening starts, an intense tropical bouquet emanates from the fruit, a harbinger of the profoundly complex flesh tasting like sweet melon and honey. The fruit is disease-tolerant during the time from harvest to arrival at the final destination.

Preliminary results show that small fruit can be kept for a few days longer than large fruit (Table 3).

Fruit gets soft when ripe. Fruit must be handled gently as it can bruise easily. Avoid storing mangos at temperatures below 50 °F. Keep fruit in a box to complete the ripening process. It

is best to place the mango stem side down at room temperature. Cover the fruit with a mesh cloth. The mango fruit is like the tree itself—it prefers warm temperatures and sunlight to extend its storage lifespan. A label on the box with storage directions is necessary for shipping. Consumers need a guide for how to store fruit at home and how to determine when it is ready to eat.

Among the various carriers available to North American online merchants, the USPS offers some of the most attractive options, especially with the aforementioned flat rate and prepaid flat rate boxes and envelopes. Flat rate boxes, by their very nature, have a known cost. They are delivered in two or three days.

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