MANGO STORAGE

Pre and Post-Harvest Storage

STOREX
CONTROLLED ATMOSPHERE

TABLE OF CONTENTS

References:

Keith Thompson, Fruit and Vegetables Harvesting

CA Davis, CA recommendations vegetables and fruits.

Methodist Un. College, Ghana, Post-harvest and Handling of Mangoes.

Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl

The Top Mango Producing Countries In The World

Rank	Area	Value (Tonnes)
1	India	18,779,000
2	China	4,771,038
3	Thailand	3,432,129
4	Mexico	2,197,313

Growing conditions

Mangoes are a strictly tropical fruit. They love the tropics. The best climate to grow mangoes is frost free with cool, dry winters and steamy, hot summers. Mangoes like growing in light and free draining soils, they don't need rich soil andgrow mainly on large trees.

Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl

Climate

The mango tree grows in tropical climates. Extended exposure to temperatures below 30°F (-1,11 ^{0}C) can kill or severely damage a mango tree.

Harvest time

Harvesting mangos early in the day will keep mangos cool and reduce water loss. However, harvesting in the early morning will result in increased flow of latex from the mango stem after picking, so proper drainage procedures should be in place prior to early morning picking. Have a plan to transport mangos to a cool, shaded place, particularly before the hottest part of the day.

Harvest maturity is judged on skin color, firmness of the flesh, size, shape and aroma. Mangos harvested when mature will ripen by themselves during storage and shipping. Mangos harvested before they are mature will not be able to ripen properly and will not develop good flavor. Mangos harvested too late will bruise easily and may develop defects such as jelly seed. Below is a description of common maturity indicators. The methods section contains a recommended procedure for determining general maturity for a mango crop.
But despite of all the ripening- and maturation indicators it is not always successful to get a homogeneous product. While a lot of mangoes are exported to distant markets it is important to get an equal ripening development. When mangoes arrive in supermarkets with a big difference in ripening it could be a disappointment for the consumer when the fruits too ripe or unripe.

Indicators:

Shape

Mango shape is the quickest, easiest, and most reliable way to gauge mango maturity. Determining mango maturity by shape is based mainly on the shoulder size and development. Mango shoulders should be full, with the shoulder connecting to the stem at less than a 90-degree angle. Rainfall and irrigation affect shoulder development such that higher amounts of rain or irrigation will cause fuller shoulders. The picture below shows an immature mango with sloping shoulders on the left and mature mango with full shoulders on the right.

Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl

Skin appearance

Skin color is not always an indicator of internal maturity or ripeness. Maturity and ripening are not related to red color and only somewhat related to green-yellow transition. Mango skin color will transition from green to yellow as the mango ripens. The following image shows a mature mango with green skin as an example of how skin color can be a misleading indicator of mango maturity.

Lenticel appearance

Kent mangoes show prominent lenticels (light colored spots) in mature fruit. However, the appearance of lenticels is not the same for all varieties and should be used with other maturity indicators to predict maturity. The picture below shows a mature Kent mango with visible lenticels (white spots).

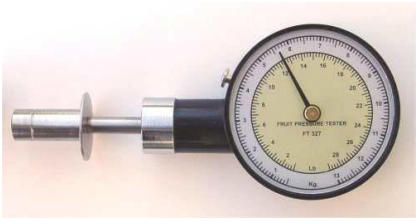
Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl

Flesh color

Flesh color is a good indicator of maturity. However, determining mango maturity through flesh color requires cutting and destroying the mango. Thus, flesh color should be used along with shape, lenticel appearance, and firmness to predict what maturity looks like in each specific crop. On the following page are internal flesh colors for Kent and Keitt mangos correlated with and brix data. Mango should be harvested at stage 2 of maturity or after.

Flesh firmness

Firmness is a useful indicator of mango development and decreases as mangos mature and ripen. The most accurate way of measuring mango flesh firmness is by testing with a penetrometer.

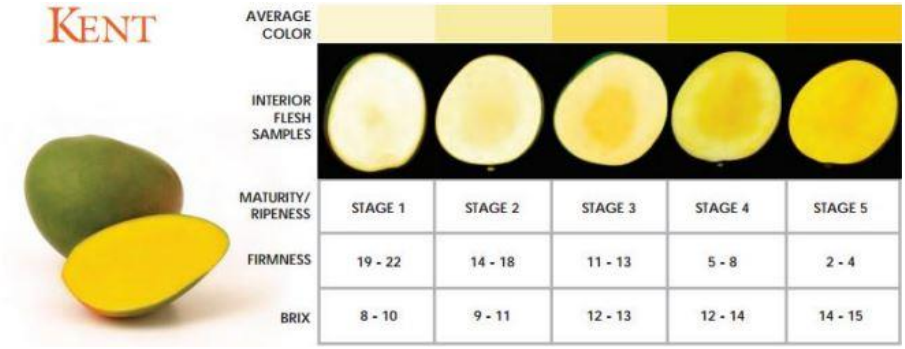


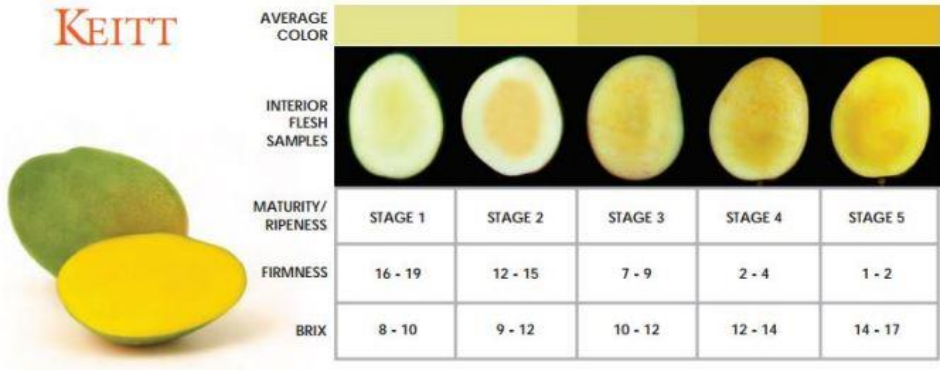
A penetrometer is a small device that measures the force needed puncture the flesh with a probe. The methods section contains a detailed description of how to use a penetrometer. Flesh firmness can also be estimated by gently squeezing the mango in their hands, but training using a penetrometer is recommended. Flesh firmness should be use with other measures such as shape, flesh color, and BRIX to determine maturity and ripening.

BRIX can be used with other measures as an indicator of maturity, but is more useful as a ripeness indicator. BRIX is mainly a measure of how much sugar is present in the mango, though other factors such as acid and pigment levels also affect BRIX readings. At harvest, mangoes are recommended to be a minimum of 7-9% BRIX. However, external factors such as irrigation and rainfall can affect BRIX measurement and

Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl

should be considered. BRIX can be measured using a refractometer and will increase as mangos mature and ripen.



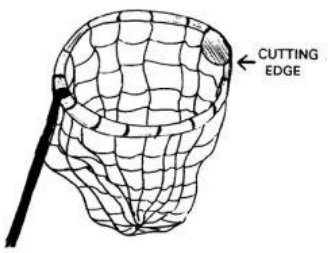


Harvest method

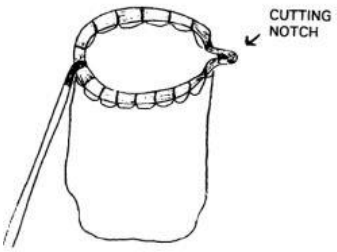
Many harvesting tools can be made or purchased to help protect mangos during harvest. One common harvesting tool is a basket on a long pole with a cutting tool attached.

Another useful tool is a canvas tube extended at an angle from a container on the ground to a person picking in a tree. Mangos dropped though a correctly constructed and situated tube will slow to a safe speed before reaching the ground container. Simple harvesting aids such as collection nets in the tree can also be used to decrease mango damage (see following picture). Any blades used for harvesting should be sharpened regularly to minimize damage to the fruit and tree. Blades with rounded tips are recommended to decrease accidental damage to the fruit. Proper training before harvesting is key to using harvesting tool correctly.

Hand woven collection bag



Canvas collection sack



Post-harvest handling

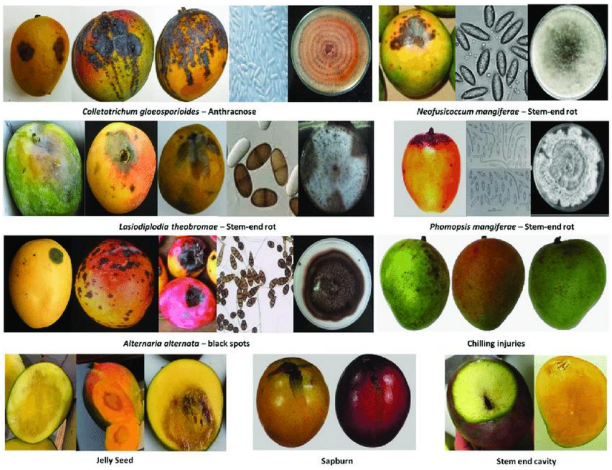
The harvested fruits are precooled to 10-12°C and then stored at an appropriate temperature. The fruits could be stored for 3-4 weeks in good condition at low temperature. Preventing chilling injury at low temperature can be overcome by keeping the fruits in 0.5 per cent ventilated polythene bags.
As indicated before mangoes could have an heterogeneous ripening pattern. Originally green mangoes for instance could during the distribution phase differ in ripening speed. Therefore packing houses use special ripening procedures. Before the ripening process with ethylene mangoes are individual inspected on ripening status, sometimes distinguished by Near Infrared Reflectance (NIR) grading equipment. The sorted mangoes could get a different temperature/ethylene treatment.
This procedures are especially also for the ready to eat approach

Post-harvest diseases

Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl

Anthracnose (caused by *Colletotrichum gloeosporioides* and occasionally *C. acutatum*) is the major fungal disease of mangoes. Major losses occur from flowering to fruit set and again after harvest. Sunken black spots appear on the surface of the fruit during ripening. The disease is most severe following periods of wet weather.

Stem end rot (*Botryosphaeria* spp., *Lasiodiplodia theobromae* and other fungi) is a soft, watery rot that develops from the stem end as fruit ripens after harvest.



Storage and Controlled Atmosphere (CA)

Storage at 6 ◦C for 10 days, 13◦C for the next 10 days and 6 ◦C for the last 10 days were recommended by Munoz *et al.* (1998). Fruits stored continuously at 6 ◦C did not develop carotenoid pigments, while the maximum storage period at 13 ◦C was less than 20 days. General refrigerated storage recommendations include:

Storage Temperature:	13 °C
Relative humidity:	85%-90%
Highest Freezing Temperature:	-1,4-29,5
Approximate storage life:	2-4 weeks

Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl

Observations and beneficial CA conditions:	3-5% O_2 +5-10% CO_2

Storing tree-ripe mangoes in controlled atmosphere storage at 12 ◦C for even 2 weeks was not successful due to zero shelf life following storage (Bender *et al.* 2000b). Storage at O2 levels of 1% resulted in the production of 'off flavors' and skin discoloration (Hatton and Reede 1966).
A longer storage period below 12 ◦C could led to serious symptoms of chilling injury as showed in the picture below(Researchgate)

General controlled atmosphere storage (ULO:ULTRA LOW OXYGEN) recommendations for some varieties were as follows:

Alphonso
- 5.6–7.2 ◦C and 85–90% r. h.
- 8–10 ◦C and 85–90% r. h. for up to 4 weeks.

Alphonso from India
- 7–9 ◦C and 90% r. h. for 7 weeks.

Alphonso from the United States
- 13 ◦C and 90% r. h. for 2–3 weeks.

Amelie
- 11 ◦C with 5%O2 and 5% CO2 for 4 weeks.

Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl

Bangalore
- 7–9 ◦C and 85–90% r. h. for 4–7weeks.

Ceylon
- 10 ◦C for 3 weeks.

Ethylene

Mangoes produce little ethylene before the ripening process has started.
At this stage, mangoes are very sensitive to exogenous ethylene which will begin the ripening procedure. As a result mangoes will begin to produce ethylene. Use of this effect is done by harvesting the unripe fruit and exposing it to exogenous ethylene in the ripening cells before or after the transfer, thus starting the process of ripening.

Ethylene treatment is best at 20-22 °C and 90-95% r. h with 100-150 ppm ethylene for 24 hours. The CO_2 should remain below 1%.

Storex Controlled Atmosphere/Beneden Havendijk 89/3295 XB's Gravendeel,the Netherlands/www.storex.nl/ tel:+31786733648/ info@storex.nl