

## AVOCADO



### ***Taxonomy***

*Persea americana* Mill., Lauraceae (Myrtle family)

### ***Botany***

Avocados originated in Central and northern South America and are now widely distributed throughout the tropics and subtropics of the world. There are three horticultural races (subspecies) of avocado, viz. the West Indian race (*P. americana* Mill. var. *americana* (*P. gratissima* Gaertn.)), the Guatemalan race (*P. nubigena* var. *guatemalensis* L. Wms.) and the Mexican race (*P. americana* Mill. var. *drymifolia* Blake (*P. drymifolia* Schlecht. & Cham.)). These races differ with respect to several morphological, physiological and chemical characteristics. The West Indian race (not native to the West Indies) is tropical in nature and intolerant of low temperature storage. The fruit are of a variable size and has a thin, smooth skin, a low oil content (3-10%) and a sweeter flavour. This race is considered by some to have the best flavoured fruit and include varieties such as Maoz, Ruchle and Waldin. The Guatemalan race is subtropical in nature and is therefore more tolerant to low temperatures. The fruit are large and has a rough skin, intermediate oil content (8-15%) and a rich flavour. Varieties that fall into this race include Edranol, Pinkerton, Reed and Gwen. The Mexican race is most cold tolerant of the three. Its fruit are small, has a high oil content (up to 30%) and a rich, anise-like flavour. Examples of varieties in this race are Duke, Northrop and Zutano. It appears that the popular Fuerte variety (12-17% oil) is a hybrid between the Guatemalan and Mexican races. There is evidence that the widely cultivated Hass variety (18-22% oil) is also a Guatemalan-Mexican hybrid. This variety is popular for its flavour and longer shelf-life. Ryan is another important example of the Guatemalan-Mexican hybrid varieties. Other Hass-like varieties include Grace, Gem, Harvest, Lamb and Maluma.

Avocado trees vary in size and shape from short and spreading to tall and erect. Flowers are small, pale-green or yellow-green in colour and born on racemes (inflorescence with stalked flowers arranged singly along an elongated unbranched axis) near the tips of the branches. The flower has six perianth lobes arranged in 2 whorls of 3 each, 9 stamens arranged in an outer circle of 6 and an inner circle of 3, and a single pistil. The single ovary is superior (attached to the receptacle above the

attachment of other floral parts) with one carpel and one ovule. A pair of orange nectar glands is located at the base of the inner stamen circle. Avocado cultivars are classified into Class A or Class B, depending on the hours of the day when it is receptive to or shedding pollen. Flowers of Class A cultivars will receive pollen in the morning while those of Class B cultivars shed pollen in the morning. The avocado fruit is a berry with a single seed surrounded by a thick fleshy mesocarp (fleshy edible portion derived from the ovary wall). With reference to its respiratory pattern during ripening, avocados are classified as climacteric.

### ***World Production***

According to FAOSTAT (<http://faostat.fao.org/site/339/default.aspx>) avocados are grown commercially in 64 countries and the world production was almost 3.9 million tonnes in 2010. The top fifteen producers for 2010 (thousand tonnes) were Brazil (152), Chile (330), China (105), Colombia (202), Dominican Republic (289), Guatemala (94), Indonesia (224), Israel (73), Kenya (113), Mexico (1107), Peru (184), Rwanda (74), South Africa (83), Spain (104), and USA (158).

### ***Nutrition***

The nutritional value\* of fresh avocado fruit per 100 g edible portion is:

Water	73%	Potassium	485
Calories	170 kcal	Sodium	7
Protein	2%		
Fat	14.7%	Vitamins (mg):	
Sugars	0.7%	Vitamin A	146 IU
Starch	0.1%	Vitamin B <sub>1</sub> (thiamin)	0.07
Fiber	6.7%	Vitamin B <sub>2</sub> (riboflavin)	0.13
		Vitamin C	10
Minerals (mg):		Niacin	1.7
Calcium	12		
Iron	0.6		
Magnesium	29		
Phosphorous	52		

\*USDA National Nutrient Database for Standard Reference, Release 25 (2013), <http://ndb.nal.usda.gov/ndb/search/list>

### ***Harvesting and Quality Indices***

Avocados do not ripen while still attached to the tree and are hand-harvested when fully mature. Harvest maturity is determined by DAFB, fruit specific gravity, size (length, diameter, volume) and dry matter or moisture content correlated with oil content. Oil content increases during fruit maturation but remains unchanged during postharvest storage at 0-20°C. Moisture content decreases as the oil content increases during maturation. When harvested immature, avocados will not ripen but become discoloured, shrivelled and rubbery. Eating quality is determined by texture and flavour, and is unfavourably affected by rancidity and off-flavours often caused by on-tree storage. Visual quality is determined by colour, size, shape and freedom from outwardly visible defects, injuries, spray residues and decay. In subtropical regions such as South Africa, early maturing fruit have better quality and postharvest characteristics.

### ***Physiological Disorders***

Due to their tropical and subtropical nature, avocados suffer chilling injury when exposed to low storage temperatures. In general, the Guatemalan and Mexican races are less susceptible to chilling injury than the West Indian race. The severity of this injury depends on the temperature, duration of exposure, cultivar, maturity at harvest and production area. External symptoms of chilling injury include pitting, scalding and blackening of the skin, increased susceptibility to pathogen attack and failure to ripen. Prolonged exposure to low temperatures can result in brown or greyish discoloration of the mesocarp and off-flavours. The presence of ethylene increases the susceptibility of avocados to chilling injury, while storage in CA reduces the incidence of chilling injury.

Internal darkening is another disorder caused by chilling, waxing and MA. This disorder is characterized by a grey to black discoloration of the pulp, starting at the distal end and around the seed. Internal darkening can be controlled by proper ventilation of shipping containers.

### ***Precooling and Storage***

Mature green avocados store well for 2-4 weeks between 5 and 13°C at 85-90% RH, depending on the cultivar, maturity at harvest and duration of storage. Harvested fruit should be cooled down soon after harvest to the recommended storage temperature of the cultivar. Precooling is done most effectively by forced-air or hydrocooling. Fruit quality can be maintained by using 'step-down' cooling in which the temperature is reduced by 1-2°C per week during shipping to a final temperature not lower than 3.5°C. The 'step-down' protocol differs for each cultivar, time in the season and growing region. Since ripe avocados are less sensitive to chilling injury, they can be stored at lower temperatures ranging from 2-4°C at 85-90% RH for up to 2 weeks. Storage in CA at 2-5% O<sub>2</sub>, 3-10% CO<sub>2</sub>, 90-95% RH and 5-7°C in the absence of ethylene can extend the postharvest-life of mature green avocados to more than 8 weeks, depending on the cultivar. After storage such fruit can still be ripened to good quality in air. The best ripening temperature after storage is 15-20°C. Avocados can be 'preconditioned' to ripen faster and more evenly by treatment with ethylene (see below). Chilling injury in avocados is reduced by storage in CA and treatment with 1-MCP. CA in conjunction with 1-MCP treatment (300-500 nL L<sup>-1</sup>) is used successfully for long distance marine container transport of Fuerte and Hass avocados. The storage-life of mature green Hass avocados has also been successfully increased through hypobaric storage at 8 kPa (60 mm Hg) and 6°C which reduces respiration and ethylene production.

### ***Ethylene***

Avocados are climacteric fruit and as such show a marked increase in ethylene production during ripening concomitant with the climacteric rise in respiration rate. Ripening of avocados is accelerated by treatment with 10-100 µL L<sup>-1</sup> (ppm) ethylene at 17-20°C for 12 to 48 hours after harvest. Careful attention should be paid to temperature and CO<sub>2</sub> management during ethylene treatment and

ripening. Early-season fruits require longer exposure to ethylene than mid or late-season fruits. Exposure to ethylene stimulates ethylene production by the fruit and removal of ethylene from the storage atmosphere increases storage-life. In CA, the low O<sub>2</sub> and high CO<sub>2</sub> levels suppress ethylene production by the fruit. Treatment with 1-MCP greatly delays ripening of avocado fruit as indicated by a delay in softening and colour change. It also reduces internal chilling injury in very susceptible cultivars.

### ***Postharvest Pathology***

Anthracnose, caused by *Glomerella cingulata*, is an important disease of avocado. Infection can occur during the growing season after which the fungus remains quiescent until the fruit begins to soften during ripening. Infected fruits initially show circular black or brown spots which, in humid conditions, can later become covered with pink spores. At this stage the underlying flesh of the fruit undergoes rapid decay and become brown with a rancid flavour. Control of this disease requires fungicide sprays in the field during fruit development. Postharvest control methods include fungicide treatments, prompt cooling to correct storage temperature, temperature maintenance during storage and marketing, and minimization of handling damage.

Stem-end rot is another important disease of avocado. This disease is caused by several fungal and bacterial species, including the fungus *Lasiodiplodia theobromae* (syn. *Botryodiplodia theobromae* and others). These fungi are saprophytes that inhabit soil, senescing flowers, dead branches and bark and injured fruit. Their spores are dispersed by wind and splashing rain drops. Decay begins at the stem-end (stem button) of the fruit and becomes visible as a small ring of brown tissue that spreads throughout the entire fruit. Since *Lasiodiplodia* is a wound parasite, most infections occur at harvest when the fungi enter the freshly cut stem. This disease is controlled by preharvest fungicide sprays, field-dipping of the cut end in fungicide wax, postharvest fungicide dips, removal of dead branches and twigs from the tree, removal and destruction of leaf litter, pruning and harvesting during dry conditions, and prompt precooling and cold storage.

Other postharvest diseases of avocado include *Alternaria* rot, blue mold rot, *Fusarium* rot, *Pestalotiopsis* rot, pink mould rot, and *Rhizopus* rot.