BASIC HARVEST AND POST-HARVEST HANDLING CONSIDERATIONS FOR FRESH FRUITS AND VEGETABLES

2.1 Harvest handling

2.1.1 Maturity index for fruits and vegetables

The principles dictating at which stage of maturity a fruit or vegetable should be harvested are crucial to its subsequent storage and marketable life and quality. Post-harvest physiologists distinguish three stages in the life span of fruits and vegetables: maturation, ripening, and senescence. Maturation is indicative of the fruit being ready for harvest. At this point, the edible part of the fruit or vegetable is fully developed in size, although it may not be ready for immediate consumption. Ripening follows or overlaps maturation, rendering the produce edible, as indicated by taste. Senescence is the last stage, characterized by natural degradation of the fruit or vegetable, as in loss of texture, flavour, etc. (senescence ends at the death of the tissue of the fruit). Some typical maturity indexes are described in following sections.

Skin colour:

This factor is commonly applied to fruits, since skin colour changes as fruit ripens or matures. Some fruits exhibit no perceptible colour change during maturation, depending on the type of fruit or vegetable. Assessment of harvest maturity by skin colour depends on the judgment of the harvester, but colour charts are available for cultivars, such as apples, tomatoes, peaches, chilli peppers, etc.

Optical methods:

Light transmission properties can be used to measure the degree of maturity of fruits. These methods are based on the chlorophyll content of the fruit, which is reduced during maturation. The fruit is exposed to a bright light, which is then switched off so that the fruit is in total darkness. Next, a sensor measures the amount of light emitted from the fruit, which is proportional to its chlorophyll content and thus its maturity.

Shape:

The shape of fruit can change during maturation and can be used as a characteristic to determine harvest maturity. For instance, a banana becomes more rounded in cross-sections and less angular as it develops on the plant. Mangoes also change shape during maturation. As the mango matures on the tree the relationship between the shoulders of the fruit and the point at which the stalk is attached may change. The shoulders of immature mangoes slope away from the fruit stalk; however, on more mature mangoes the shoulders become level with the point of attachment, and with even more maturity the shoulders may be raised above this point.

Size:

Changes in the size of a crop while growing are frequently used to determine the time of harvest. For example, partially mature cobs of *Zea mays saccharata* are marketed as sweet corn, while even less mature and thus smaller cobs are marketed as baby corn. For bananas, the width of individual fingers can be used to determine harvest maturity. Usually a finger is placed midway along the bunch and its maximum width is measured with callipers; this is referred to as the calliper grade.

Aroma: Most fruits synthesize volatile chemicals as they ripen. Such chemicals give fruit its characteristic odour and can be used to determine whether it is ripe or not. These doors may only be detectable by humans when a fruit is completely ripe, and therefore has limited use in commercial situations.

Fruit opening:

Some fruits may develop toxic compounds during ripening, such as ackee tree fruit, which contains toxic levels of hypoglycine. The fruit splits when it is fully mature, revealing black seeds on yellow arils. At this stage, it has been shown to contain minimal amounts of hypoglycine or none at all. This creates a problem in marketing; because the fruit is so mature, it will have a very short post-harvest life. Analysis of hypoglycine 'A' (hyp.) in ackee tree fruit revealed that the seed contained appreciable hyp. at all stages of maturity, at approximately 1000 ppm, while levels in the membrane mirrored those in the arils. This analysis supports earlier observations that unopened or partially opened ackee fruit should not be consumed, whereas fruit that opens naturally to over 15 mm of lobe separation poses little health hazard, provided the seed and membrane portions are removed. These observations agree with those of Brown et al. (1992) who stated that bright red, full sized ackee should never be forced open for human consumption.

Leaf changes:

Leaf quality often determines when fruits and vegetables should be harvested. In root crops, the condition of the leaves can likewise indicate the condition of the crop below ground. For example, if potatoes are to be stored, then the optimum harvest time is soon after the leaves and stems have died. If harvested earlier, the skins will be less resistant to harvesting and handling damage and more prone to storage diseases.

Abscission:

As part of the natural development of a fruit an abscission layer is formed in the pedicel. For example, in cantaloupe melons, harvesting before the abscission layer is fully developed results in inferior flavoured fruit, compared to those left on the vine for the full period.

Firmness:

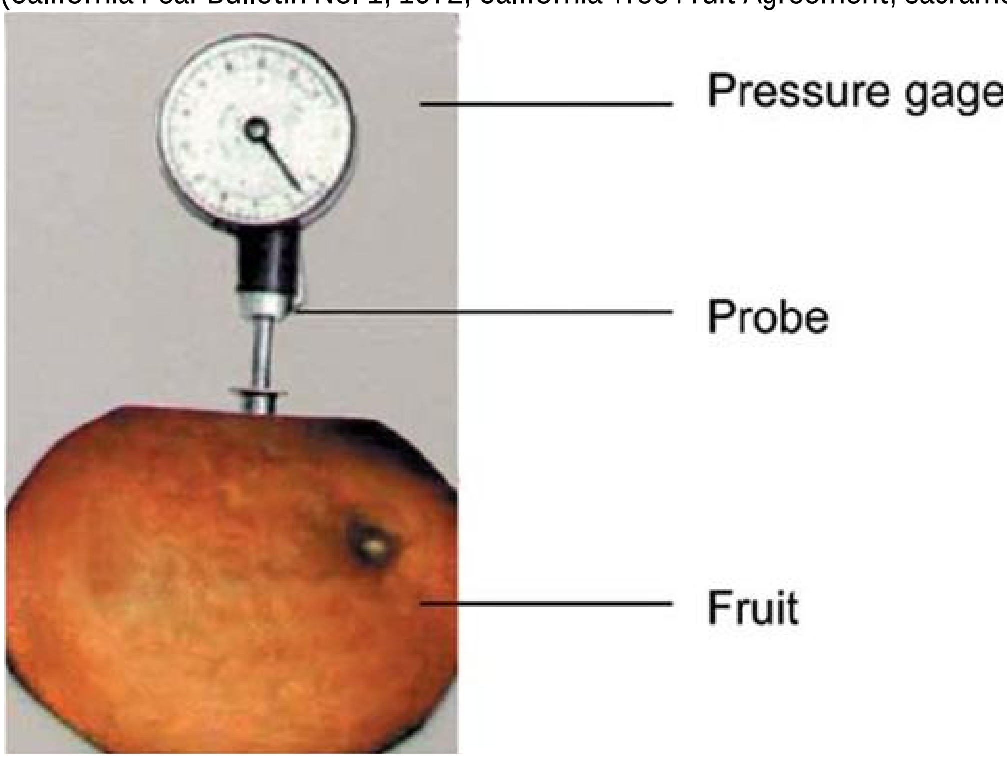
A fruit may change in texture during maturation, especially during ripening when it may become rapidly softer. Excessive loss of moisture may also affect the texture of crops. These textural changes are detected by touch, and the harvester may simply be able to gently squeeze the fruit and judge whether the crop can be harvested. Today sophisticated devices have been developed to measure texture in fruits and vegetables, for example, texture analyzers and pressure testers; they are currently available for fruits and vegetables in various forms. A force is applied to the surface of the fruit, allowing the probe of the penetrometer or texturometer to penetrate the fruit flesh, which then gives a reading on firmness. Hand held pressure testers could give variable results because the basis on which they are used to measure firmness is affected by the angle at which the force is applied. Two commonly used pressure testers to measure the firmness of fruits and vegetables are the Magness-Taylor and UC Fruit Firmness testers (Figure 2.1). A more elaborate test, but not necessarily more effective, uses instruments like the Instron Universal Testing Machine. It is necessary to specify the instrument and all settings used when reporting test pressure values or attempting to set standards.

The Agricultural Code of California states that "Bartlett pears shall be considered mature if they comply with one of the following: (a) the average pressure test of not less than 10 representative pears for each commercial size in any lot does not exceed 23 lb (10.4 kg); (b) the soluble solids in a sample of juice from not less than 10 representative pears for each commercial size in any lot is not less than 13%" (Ryall and Pentzer, 1982). This Code defines minimum maturity for Bartlett pears and is presented in Table 2.1.

Table 2.1 Minimum maturity standard (expressed as minimum soluble solids required and maximum Magness-Taylor test pressure allowed) of fresh Bartlett pears for selected pear size ranges (adapted from Ryall and Pentzer, 1982).

Pear Size(max diameter;cm)	*6.0 cm to 6.35 cm*	*£ 6.35 cm*
Minimum Soluble Solids (%)	**Maximum Test Pressure (kg)**	
Below 10%	8.6	9.1
10%	9.1	9.5
11%	9.3	9.8
12%	9.5	10.0

Table 2.1 can be simplified by establishing a minimum tolerance level of 13% soluble solids as indicator of a pear's maturity and in this way avoid the pressure test standard control (California Pear Bulletin No. 1, 1972, California Tree Fruit Agreement, Sacramento,



CA):

Juice content:

The juice content of many fruits increases as the fruit matures on the tree. To measure the juice content of a fruit, a representative sample of fruit is taken and then the juice extracted in a standard and specified manner. The juice volume is related to the original mass of juice, which is proportional to its maturity. The minimum values for citrus juices are presented in Table 2.2.

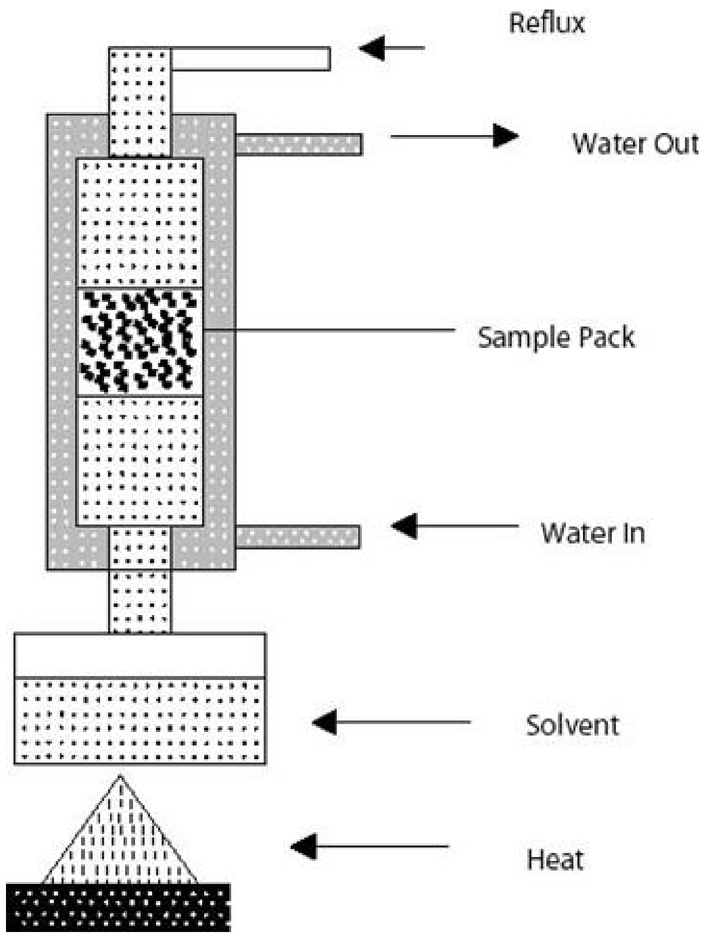
Table 2.2 Minimum juice values for mature citrus.

Citrus fruit	**Minimum juice content (%)**
Naval oranges	30
Other oranges	35
Grapefruit	35
Lemons	25
Mandarins	33
Clementines	40

Oil content and dry matter percentage:

Oil content can be used to determine the maturity of fruits, such as avocados. According to the Agricultural Code in California, avocados at the time of harvest and at any time thereafter, shall not contain in weight less than 8% oil per avocado, excluding skin and seed (Mexican or Guatemalan race cultivars). Thus, the oil content of an avocado is related to moisture content. The oil content is determined by weighing 5-10 g of avocado pulp and then extracting the oil with a solvent (e.g., benzene or petroleum ether) in a destillation column. This method has been successful for cultivars naturally high in oil content (Nagy and Shaw, 1980).

Figure 2.2 Distillation column used for oil determination.



A round flask is used for the solvent. Heat is supplied with an electric plate and water recirculated to maintain a constant temperature during the extraction process (Figure 2.2). Extraction is performed using solvents such as petroleum ether, benzene, diethyl ether, etc., a process that takes between 4-6 h. After the extraction, the oil is recovered from the flask through evaporation of the water at 105°C in an oven until constant weight is achieved.

Moisture content

During the development of avocado fruit the oil content increases and moisture content rapidly decreases (Olaeta-Coscorroza and Undurraga-Martinez, 1995). The moisture levels required to obtain good acceptability of a variety of avocados cultivated in Chile are listed in Table 2.3.

Table 2.3 Moisture content of avocado fruit cultivated in Chile.

Cultivar	**Moisture content** (%)
Negra de la Cruz	80.1
Bacon	77.5
Zutano	80.5

Fuerte	77.9
Edranol	78.1
Hass	73.8
Gwen	78.4
Whitesell	79.1

Sugars:

In climacteric fruits, carbohydrates accumulate during maturation in the form of starch. As the fruit ripens, starch is broken down into sugar. In non-climacteric fruits, sugar tends to accumulate during maturation. A quick method to measure the amount of sugar present in fruits is with a brix hydrometer or a refractometer. A drop of fruit juice is placed in the sample holder of the refractometer and a reading taken; this is equivalent to the total amount of soluble solids or sugar content. This factor is used in many parts of the world to specify maturity. The soluble solids content of fruit is also determined by shining light on the fruit or vegetable and measuring the amount transmitted. This is a laboratory technique however and might not be suitable for village level production.

Starch content:

Measurement of starch content is a reliable technique used to determine maturity in pear cultivars. The method involves cutting the fruit in two and dipping the cut pieces into a solution containing 4% potassium iodide and 1% iodine. The cut surfaces stain to a blue-black colour in places where starch is present. Starch converts into sugar as harvest time approaches. Harvest begins when the samples show that 65-70% of the cut surfaces have turned blue-black.

Acidity:

Sacks are commonly used for crops such as potatoes, onions, cassava, and pumpkins. Other types of field harvest containers include baskets, buckets, carts, and plastic crates. For high risk products, woven baskets and sacks are not recommended because of the risk of contamination.

Depending on the type of fruit or vegetable, several devices are employed to harvest produce. Commonly used tools for fruit and vegetable harvesting are secateurs or knives, and hand held or pole mounted picking shears. When fruits or vegetables are difficult to catch, such as mangoes or avocados, a cushioning material is placed around the tree to prevent damage to the fruit when dropping from high trees. Harvesting bags with shoulder or waist slings can be used for fruits with firm skins, like citrus and avocados. They are easy to carry and leave both hands free. The contents of the bag are emptied through the bottom into a field container without tipping the bag. Plastic buckets are suitable containers for harvesting fruits that are easily crushed, such as tomatoes. These containers should be smooth without any sharp edges that could damage the produce. Commercial growers use bulk bins with a capacity of 250-500 kg, in which crops such as apples and cabbages are placed, and sent to large-scale packinghouses for selection, grading, and packing.

2.1.4 Packing in the field and transport to packinghouse

Berries picked for the fresh market (except blueberries and cranberries) are often mechanically harvested and usually packed into shipping containers. Careful harvesting, handling, and transporting of fruits and vegetables to packinghouses are necessary to preserve product quality.

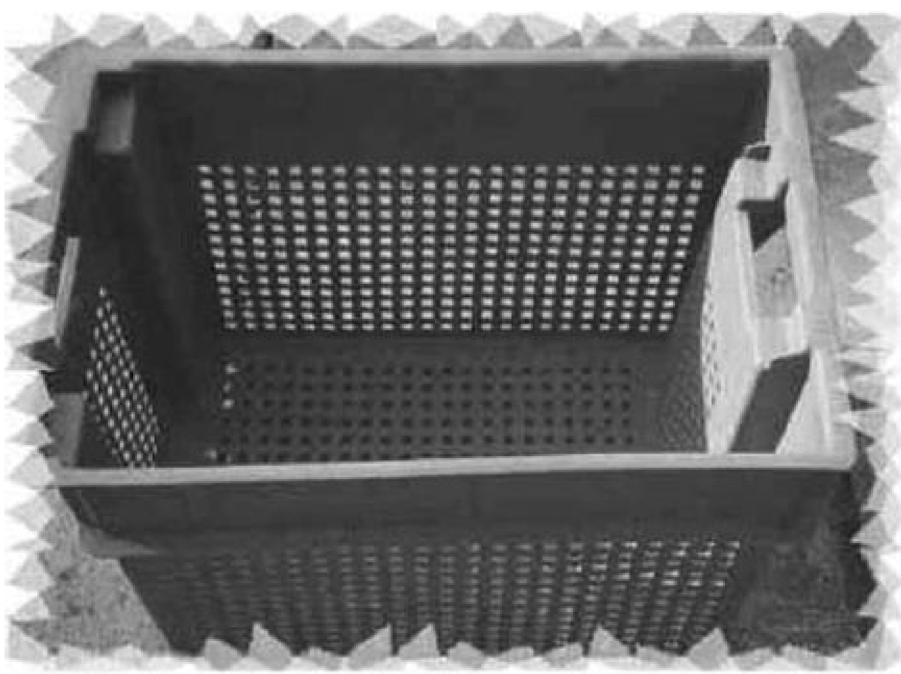
Polyethylene bags:

Clear polyethylene bags are used to pack banana bunches in the field, which are then transported to the packinghouse by means of mechanical cableways running through the banana plantation. This technique of packaging and transporting bananas reduces damage to the fruit caused by improper handling.

Plastic field boxes:

These types of boxes are usually made of polyvinyl chloride, polypropylene, or polyethylene. They are durable and can last many years. Many are designed in such a way that they can nest inside each other when empty to facilitate transport, and can stack one on top of the other without crushing the fruit when full (Figure 2.4).

Figure 2.4 Plastic field boxes with nest/stack design.



Wooden field boxes:

These boxes are made of thin pieces of wood bound together with wire. They come in two sizes: the bushel box with a volume of 2200 in^3 (36052 cm^3) and the half-bushel box. They are advantageous because they can be packed flat and are inexpensive, and thus could be non-returnable. They have the disadvantage of providing little protection from mechanical damage to the produce during transport. Rigid wooden boxes of different capacities are commonly used to transport produce to the packinghouse or to market. (Figure 2.5).

Figure 2.5 Typical wooden crate holding fresh tomatoes.

Bulk bins:

Bulk bins of 200-500 kg capacity are used for harvesting fresh fruits and vegetables. These bins are much more economical than the field boxes, both in terms of fruit carried per unit volume and durability, as well as in providing better protection to the product during transport to the packinghouse. They are made of wood and plastic materials. Dimensions for these bins in the United States are 48 × 40 in, and 120 × 100 cm in metric system countries. Approximate depth of bulk bins depends on the type of fruit or vegetable being transported (Table 2.5)

Table 2.5. Approximate depth of bulk bins.

Commodity	**Depth (cm)**
Citrus	70
Pears, apples	50
Stone fruits	50
Tomatoes	40