Guidelines for postharvest handling of some fruits, vegetables and dry grain

Nderitu, J. H. and Imungi, J. K.
Faculty of Agriculture
University of Nairobi
P. O. Box 30197, Nairobi

Association For Better Land Husbandry(ABLH)
P. O. Box 601, Village Market, Nairobi
<table>
<thead>
<tr>
<th>Table of content</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>1</td>
</tr>
<tr>
<td>Introduction on post harvest of fruits</td>
<td>3</td>
</tr>
<tr>
<td>Avocado</td>
<td>5</td>
</tr>
<tr>
<td>Bananas</td>
<td>7</td>
</tr>
<tr>
<td>Mango</td>
<td>10</td>
</tr>
<tr>
<td>Paw paw</td>
<td>12</td>
</tr>
<tr>
<td>Passion fruit</td>
<td>14</td>
</tr>
<tr>
<td>Pineapples</td>
<td>16</td>
</tr>
<tr>
<td>Vegetables</td>
<td>18</td>
</tr>
<tr>
<td>Dry grains</td>
<td>24</td>
</tr>
<tr>
<td>Maize</td>
<td>25</td>
</tr>
<tr>
<td>Beans</td>
<td>27</td>
</tr>
<tr>
<td>Green grams</td>
<td>29</td>
</tr>
<tr>
<td>Sunflower</td>
<td>30</td>
</tr>
<tr>
<td>Soybeans</td>
<td>33</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>34</td>
</tr>
<tr>
<td>Macadamia</td>
<td>36</td>
</tr>
</tbody>
</table>
FRUITS (Avocado, banana and plantain, mango, papaya, passion fruit and pineapple).

Most fruits are categorized as perishables. They have water contents above 50%. They are eaten mainly fresh for their nutrition and thirst quenching properties. They are, however, also processed into various convenient and more shelf-stable products such as beverages (juices, nectars and drinks), jams and jellies. Recently also, wine has been manufactured from non grape fruits such as the papaya.

Because of their high water content, fruits deteriorate very rapidly after harvest. The main causes of deterioration are transpiration (water loss) which causes shriveling, respiration which breaks down the constituents, principally sugar and also accelerates senescence (softening) and microorganisms (bacteria, yeasts and molds) which cause fruit rotting. All these deteriorative factors are accentuated by high temperatures (heat in the fruit) and any injury to the fruit. Fruits after harvest should therefore be kept as cool as possible and without any physical injury (blemishes, cuts etc).

Most fruits are preferred ripe. Ripeness refers to those physical and chemical changes which lead to development of desirable eating quality and is not restricted to change in colour alone. Most fruits are therefore ripened before consumption. Some fruits such as the pineapple and all the citrus fruits will not ripen after detachment from the plant. They are therefore harvested when they are adequately ripe to have developed good eating quality. Most other fruits, the mango, the banana, the avocado, the papaya etc., will ripen after harvest. They are therefore harvested at full maturity or at stage in ripening which
will allow for development of the desired eating quality. Such fruits are stored to delay ripening because once the ripening has set in, deterioration is very rapid.

Fruits that ripen after detachment are scientifically referred to as climacteric, while those that do not ripen after detachment are referred to as non-climacteric. All fruits and vegetative plant material produce small quantities of ethylene, a ripening hormone. Much higher levels of ethylene are produced by the climacteric fruits during the ripening process. Climacteric fruits should not be stored near ripe or ripening fruits to avoid premature or unwanted ripening. There are other chemicals that mimic ethylene in fruit ripening. These chemicals include the constituents of a burning candle as wax, or any slow burning material. Climacteric fruits should therefore not be stored in areas where smoke is likely to enter because this is likely to trigger unwanted ripening which can not be stopped.
AVOCADO

Avocados are climateric i.e they will ripen after detachment from the plant.

Harvesting

- Mature avocado fruits are preferably harvested by snapping with a sharp blade rather than snapping by hand. The latter method though labour intensive introduces wounds in the stem end of the fruit. This acts as easy entry for spoilage microorganisms.
- After detachment, the fruit should be brought gently to the ground, not chopped from high up in the tree to avoid any physical injury. Harvesting into a basket or in such container high on the tree is recommended.
- If possible, harvesting should be done early in the morning. At that time the temperatures and the fruit heat are low.

Postharvest handling

- Transport from the harvest point to the packing place if different should be with care to avoid physical damage to fruits
- Blemished fruits and those that were snapped from the plant should be separated out. If harvesting as by snapping, then only those which physical injury or other defects besides the stem end wounds should be separated out.
- The sound fruits should be treated by dipping in 100-150ppm solution of hypochlorite for two minutes to sanitize the fruits especially if harvesting were done by snapping. Commercial preparations of hypochlorite are available (see milton solution). Directions for dilution are available from the vendors, manufactures or your local horticultural extension officer.
• For packaging, fruits are then preferably sorted out into two-three grades of similar size.

• Fruits should be transported to the market packaged in cartons or boxes to avoid excess bruising and heat build up. Simple wooden boxes can be constructed from locally available wood. The walls of the boxes can then be first lined with green leaves (eg. Banana leaves) before placing in the fruits. Not more than 50-60 fruits should be packed in each box or carton. The cartons should be packed into the truck in such a manner that no pressure is expected to the fruits by the neighbouring carton. Transportation of the fruits as a heap at the back of the truck is not recommended.

• Once on the truck, the fruits should be provided with shade to avoid heat build up. Canvass, leaves or jute and not polythene are recommended.

• For storage, the fruits can be packaged or not packaged. If not packaged, the fruits should be stored on a cushioned floor as heaps not more than 3-4 fruit layers high

• The fruits should be stored in a cool place.

• For the local markets, the fruits can be stacked on a platform as on the floor, but the stacks should not be too high. They should be provided with shade. Occasional sprinkling of the fruits with clean water helps to maintain the temperature low.

• For the far away markets, the fruits should be transported packaged with shade provision as soon as possible after harvest.
BANANA

Banana refers to the fruit that is often ripened and eaten as dessert. Plantain refers to the fruit that is mainly used without ripening and for cooking. Bananas and plantains are highly perishable and are climacteric fruits.

Harvesting of banana postharvest handling

- Banana and plantain are harvested at the mature green stage. Maturity indices pertain to the number of days from flowering, angularity of the fingers in cross section and size of finger and are known by the growers.
- The harvesting is performed by cutting the pseudostem to prevent physical injury on the event of falling to the ground. For the banana plants which are too high for the bunch to be reached by the harvester while standing on the ground, a ladder can be used or the plant can be pulled gently towards the ground for the bunch to be reached.
- The banana bunch is debelled (remove the male bud) and trimmed (to remove the excessive pseudostem).
- If necessary the banana bunch is dehanded (separated into hands) or cut into clusters (two or more hands together).
- The cut hand is then washed in a solution of 20% chlorine (see Milton solution or Reckitts sterilizing fluid) to sterilize them and to prevent the catex from the cut fruits staining the peel of the fruits, then drip dried.
- It is easier to package hands but the preparation into hands is labour intensive.
• The hands would then be packed in fibreboard cartons or in wooden boxes.

• The cartons would be lined with polythene or the hands would be wrapped in polythene.

• Packaging of a whole bunch is less labour intensive but they are more difficult to pack in cartons or wooden crates.

• Whole bunches can, however, be placed in gunny sacks with or without wrapping with polythene paper.

• The bunches can also be wrapped with green banana leaves, better still first with polythene paper then with green banana leaves. The banana leaves wrap should be at least two layers.

• The banana bunches can also be wrapped with green leaves then placed in gunny bags.

• The bananas bunches are then stored into the transportation truck as compactly as possible to avoid relative movement among them.

• As much as possible, the bunches should be transported, to far away markets with proper provision of shade.

• Transportation where no shade provision is possible is done on bus tops. If this is the case, then the bunches should be better packaged than when shade is provided. This prevents the fruits from a possible sun scald.

• Banana fingers which have experienced bruising or sun scorching do not ripen properly. They leave dark patches in the affected areas.
Simple Banana Ripening Techniques

- Prepare banana bunch, hands or clusters as has already been described.
- Drill a small hole in the stem and put in some salt or sugar. Place the bunch as the hands or clusters in an enclosed area (box, old tank, polythene bag etc., Polythene bag if used should be perforated.
- Place the bunch(es) or pack the hands or clusters in an enclosed area. Burn candle or wax and direct the smoke to the bananas for about 3-4 hours. The bananas will burst into ripeness in less than 12 hours depending on the variety.
- Pack the bananas in an enclosed area together with any fruits that have already began to ripen (including other bananas). The ethylene gas from the ripening fruit will trigger the required ripening.

These techniques would result in uniform colour change of the banana fingers except for the areas of the skin that were bruised or had sun scald.
MANGO

Many varieties of mango are produced in Kenya but only few varieties are of real commercial value. The processes described here pertain to commercial fruits.

Harvesting

- Mangoes are harvested at a stage which will allow proper ripening. Mangoes are climacteric. Mango maturity at lowest is determined by counting the days from fruit set (specified for specific varieties), colour charge (green to yellow) and fruit size. Harvesting will be done over long period, because the fruits on the same tree are differing ages.

- The mangoes are harvested by snapping with hands or snipping with a sharp blade. Optimum harvesting involves using shears and cutting the stem 10-20mm away from the fruit. This technique reduces to later exudation and staining as well as possibility of fungal organisms entering. They should be harvested into baskets or containers and not be allowed to fall to the ground below to avoid physical injury. The stalks should be cut to approximately 20mm.

- If possible, harvesting should be carried out early in the morning to take advantage of the low temperatures.

Postharvest handing

- The harvested fruits should immediately be placed under shade if they are not harvested early in the morning.

- The fruits are sorted to remove those with blemishes, diseased ones and the misshapen ones.
• The sound fruits are then washed with a 20% hypochlorite solution to sterilize them and to remove the latex which could stain the skins. They are drip dried.

• The fruits are packed in wooden or plastic crates at the rate of 40-60 fruits per crate for purposes of transporting either to the market or to the exporters packhouse.

• Wooden crates can be fabricated from locally available material (wood or straw) and lined with either green or dry banana leaves to cushion the fruits from the walls prior to packing.

• The fruits should be transported with provision of shade to avoid temperature rise and possible scald by the sun.

• For local vending, the fruits can be stacked on a raised platform under a shed and constantly sprinkled with clean water to keep the temperatures down.

Simple ripening of the mango fruit

Similar to the bananas except that mangoes take longer to respond
PAPAYA OR PAWPAW

The papaya also known as the pawpaw is a climacteric fruit. It is highly perishable: more highly perishable than other fruits. The papaya is very low in acidity and therefore it is also spoilt by bacteria besides yeasts and moulds.

Harvesting of the papaya

- The papaya can be harvested at colour break but in order to develop good eating quality, it should be harvested at one-third ripe. The ripening starts on the apical end.
- Harvesting should be done by snapping the fruit and placing it in a basket or some other container and fruits should not be dropped to the flour to avoid physical injury. Fruits that are too high up the tree to be reached from the ground can be reached by using a ladder or such other device that helps to bring them down gently.
- Harvest early in the morning to take advantage of the low morning temperatures. If this is not possible, the fruits should be transferred to a shade as soon as they are harvested.

Postharvest handling

- The fruits are sorted to remove the blemished and the diseased ones.
- The sound fruits are washed with 20% hypochlorite solutions and drip dried. This sterilizes the surface and removes the latex that may stain the peel.
- If possible the papaya fruits can be dipped for about 10-20 minutes in warm water at 45-50°C. This action removes dish and latex as well as microorganisms from the surface. It also helps the latex just below the skin to solidify thus thinning the
skin. The process is, however, difficult to control and can result in scald of the skin. Scalded skin does not ripen properly and shows out as dark areas on a ripe fruit.

- The fruits are packaged in fibreboard cartons, wooden crates or plastic crates. Wooden crates can be fabricated very simply using locally available material. Before placing the fruits in the wooden crates, it is advisable to line the inner surface with available cushion material. Better still, individual fruits can be placed in perforated polythene bags. Do not pack more than two layers of fruits in a crate.

- For transportation, the crates are stored in the truck and provided with shade.

- If shade provision is not possible, the crates after filing with the fruit should be covered with heat insulating material such as paper, dry or green banana leaves or gunny bag material to prevent sun scald.

- Avoid transportation of papaya fruits in gunny or polythene bags for this leads to physical injury which accelerates deterioration and interferes with ripening.

- For local vending, the fruits can be stocked on wooden racks and provided with simple shade. Occasional sprinkling of the fruits with clean water helps to keep the temperatures down.

Simple ripening of papaya fruits.

- Papaya fruits ripening can be initiated in just the same manner as described for other fruits (see banana and mango).
PASSION FRUIT

There are two types of passion fruit, the yellow and the purple. The purple passion fruit will be dealt with here as it is the one that is common in the tropical regions. The passion fruit is non-climacteric

Harvesting

- The passion fruit is harvested when it is at least 75% ripe. Ripeness is indicated by a change of the skin from green to purple. At the same time, the flesh changes from white to orange while the seeds change in colour from white to black.
- The fruits are preferably harvested by snipping with a sharp blade to leave a stem of about 5mm. Shears are quite appropriate for harvesting passion fruits. Snapping results in the stem cutting very close or even into the skin and may result in wounds which are easy entry of microorganisms.
- Passion fruits should be harvested in baskets as such other containers and should immediately be transferred to the shade if the ambient temperatures are high at harvest.

Postharvest handling

- The fruits are sorted to remove the shriveled and the blemished ones. The sound ones are sold for the fresh market while the blemished and the shriveled can go for processing.
- Passion fruits may or may not be washed with hypochlorite solution, Washing, however, sterilize the skin and ensures a longer shelf-life.
• For transportation to far away markets, passion fruits can be packaged in fibreboard cartons, or wooden or plastic crates. They are then stored in stacks in a truck provided with shade. If there is no shade provision in the truck, the fruit containers should be properly covered with heat insulation material. The fruits can also be transported in gunny or plastic bags, but this form of packaging results in more fruit damage during transport than use of crates or cartons.

• For local vending, the fruits are best packaged 20-25 fruits in perforated polythene bags. Perforation prevents build up of moisture from the fruit respiration. The moisture condenses and wets the fruits surface which encourages microbial growth. During the vending, the fruits should be kept under shade.
PINEAPPLES

Pineapples are non climacteric fruits. They do not continue to ripen after harvest.

Harvesting

- Pineapples are harvested when they are at least 50-75% ripe. Ripeness of the fruit is estimated by the fruit surface that is yellow and the percentage of eyes that are yellow. Good stage of harvesting is when 5-40% of the eyes are yellow. Above this, the fruits will be too soft and the physical damage during transportation will be high. Fruits with less than 5% yellow eyes can be harvested if the transportation takes 7-14 days (overseas market).

- The fruits are harvested by snapping from the stalk by hand using a downward motion. They are then placed in crates and left under shade until transported to a packhouse. Transport in gunny or plastic bags causes mechanical damage and increases the level of fruit rejection.

Postharvest handling

- At the packing facility, the stems are trimmed to 20mm while the crown are trimmed to about 100mm. Smaller crowns and stems will encourage water loss and fruit shriveling.

- The fruits are then sorted to remove undersize, oversize, over-ripe, under-ripe (depending on the market requirements), and the damaged (insect, fungal or physical damage).

- Whole fruits of the required characteristics go for the fresh market while the reject can go for processing or can be sold locally for lower prices.
- The whole fruits are washed with either 20% solution of hypochlorite or Dowicide A (sodium-2-Phenylphenylate) at a concentration of 7g per litre of clean water after which they are drip dried.

- The fruits are graded according to stage of ripeness and the fruit size as the market requires.

- Pineapples are packaged according to grade. Fruits in the same package should be approximately the same size and degree of ripeness.

- The fruits can be packed in fibreboard cartons, wooden or plastic crates. Preferred method of packing is to place the fruit vertically, stem and down and to place dividers between the individual fruits to prevent frictional damage. In order to do away with the dividers, the fruits can be placed in perforated polythene bags of a high gauge (500 or 100) before packing in the carton or crate. The number of fruits in each crate is determined by the size of the container which in turn determined by the market. Fruits can also be packed horizontally in which case they are placed in alternate directions. If more than one layer is packed in such a case, then a strong divider should be placed between the cards.

- The fruits are loaded onto the transport system in packages and transported under shade. If the transport system has no shade provision, then the fruits in each individual package should be provided with shade.

- For local vending, the fruits can be stacked on a rack or placed in a container and provided with shade.
VEGETABLES

Baby corn and Sweet corn

Baby corn and Sweet corn are categorized as vegetables. Just like fruits and even more vegetables are highly perishable after harvest. The degree of perishability, however, depends on the vegetable. Those vegetables with high surface area and low volumes (high surface area: volume ratio) are the most highly perishable. These include the green leafy vegetables and small grains.

Perishability also depends on the stage of harvesting (commercial maturity). Immature vegetables are more highly perishable than mature ones. The main postharvest deteriorative factors of vegetables are transpiration (water loss leading to shrivelling or wilting depending on the commodity), respiration (leading to loss of sugar and therefore sweetness) and microbiological damage (leading to rotting).

Baby corn and sweet corn are harvested at their optimum eating quality which is before physiological maturity is reached. They are eaten for their sweetness which is due to the sugar they have accumulated then. Baby corn and sweet corn are therefore highly perishable after harvest and the sweetness can be lost within hours if proper postharvest management is not instituted.

The main postharvest management of baby corn and sweet corn is designed to control those factors that promote respiration and transpiration. The most important of these is temperature. Keeping down temperature ensures prolonged shelf life of the two commodities.
Baby corn

Baby corn consists of immature cob with immature seeds. The cob and seeds are therefore eaten and both are sweet at the primary stage of harvesting. Although initially all varieties of corn (maize) can be used to produce baby corn, some varieties lead themselves to yielding better quality vegetable than others.

Harvesting Baby corn:

Young ears of baby corn are harvested about 47-50 days after planting. The tassel of the male flower should be removed 45 days after planting or before pollen shedding depending on variety. Early ears are ready for harvest three days after detasseling, then the top ears have a maximum inner cob size of 9 cm in length and 1.0 to 1.5 cm in width, and 2.5 cm of long silk have emerged from the tips. The top ears are ready to harvest within three to five days of the top ears. Normally two to three ears should be obtained on each plant.

Baby corn ears that are destined for the fresh market are harvested as soon as the silk emerges or up to a maximum of two days afterwards. Silk that are exposed for four days or more are used for processing not for the export market.

Ears are harvested by using a knife or secateurs to cut the stem. Ears should not be snapped or broken because either action puts pressure on the cob and can cause mechanical damage.

Wherever possible, harvesting should be carried out in the morning to take advantage of the low temperatures. Then moisture content is high and the product heat is low. Harvesting can be conducted for 9 to 14 days once it starts and can be carried out every other day.
Post harvest handling

Baby corn ears should be inspected and sorted to leave only those that are uniform in maturity, colour, shape, size and kernel coverage, and free from defects. Baby corn ears showing signs of disease or damage from insects, mechanical injury or water should be discarded.

Baby corn should be trimmed uniformly to remove flag leaves and long shanks. If these are left on the corn, the ears will be difficult to pack and water loss will occur.

Precooling must be carried out within one to two hours of harvest. If the ears of corn are transported in bulk without precooling, the temperature of the uncooled ears will increase as a result of the heat that is produced by respiration.

Undue water loss from the kernels should be avoided as this leads to the lowering of the quality through denting of the kernels. To prevent this, the corn must be cooled rapidly. If cooling can not be commenced appropriately, then commodity should be moved to a shade.

The best method of precooling is hydrocooling (use of water) which can be done to ears with or without husks. If the ears are dehusked, however, more care should be taken to avoid mechanical damage to the exposed kernels.

For any one hour delay in cooling, the produce losses 10-12 hours of shelf life, which in this case is loss of sweetness.

Many hydrocooling systems exist but for small operations, the ears of the corn can just be flooded with fresh river or stream water. This can be through immersion or pouring water on the produce.
The produce can be cooled in the package out of the package. If they are to be cooled in the packing, then wettable materials like paper can not be used for the package, but wood, plastic and metal can be used.

After precooling to prevent microbial damage, the baby corn is dipped in a solution containing 100-150 ppm and drip dried (Hint, prepare the solution by dissolving 2 ml of milton solution of 20% to 1 litre with clean water).

Baby corn is graded in various grades depending on the market (especially export market), but the following can be a guide to grading in terms of size:

- 6 to 8 cms
- 8 to 10 cms
- 10 to 12 cms

The baby corn of the same grade is packed in fibreboard cartons, wooden or plastic crates and these are stored in a truck for transportation. Do not package in gunny or plastic bags or heap in trucks for this encourages temperature build up. The packaged baby corn are taken to the market under cooling or at least provision of shade to ensure very little temperature rise.

SWEET CORN

Baby corn consists of immature seeds on an immature cob. However, the cob in sweet corn is more mature than that for baby corn. The kernels are sweet at the primary stage of harvesting. All varieties of corn (maize) can be used for producing sweet corn but some varieties lend themselves better to production of high quality corn.
**Harvesting of sweet corn**

For the recommended varieties, harvesting can be done approximately 75 days from seedling.

Harvesting is done approximately 21 days after the silks have appeared when the weather is normal.

The proper stage of harvesting can also be done by simple testing as follows: peel; the husk off the tops of a few ears and press the kernels with the thumbnail. If the kernels burst open with forces, it is the right stage for harvesting (called the milking stage). One can also assess maturity by feeling the tightness of the ear tops or by observing the conditions of the silk.

Harvesting is done by cutting rather than snapping the ears to avoid bruising the kernels. If possible, harvesting is done very early in the morning to take advantage of the low temperatures and to avoid accumulation of field heat in the produce.

**Post harvest handling:**

Except for grading, all postharvest handling of the sweet corn is similar to that of baby corn with the following additions:

Sweet corn can be packaged dehusked or with the husks. The dehusked kernels are however properly silked (removal of the silk) and trimmed. It is then graded. For grading of both dehusked and sweet corn with husks, consult the market. The dehusked sweet corn is more perishable than corn in husk and therefore the control of temperature should even be more strict to avoid loss of sweetness.
The dehusked sweetcorn can be wrapped as single or multiple units with polythene paper. This helps greatly to control respiration. The wrapped cobs can then be packaged in cartons or crates as already described.
DRY GRAINS AND NUTS (Maize, beans and green grams, soy beans, groundnuts and macadamia nuts)

Dry grains and nuts are considered as stable products in storage. They have moisture contents well below 50% and their stability in storage is dependent on the fact that most microorganisms can not grow and most chemical and biochemical reactions are substantially slowed down under these conditions.

The optimum moisture content for storage of dry grains and nuts lies between 13-15%. Beyond this moisture content, grain could respire in storage and encourage the growth of moulds, and chemical and biochemical reactions could take place to develop in legumes what is referred to as Hard to Cook (HTC) property. High moisture content also make it easy for grain penetration by the various insect pests.

Control of moisture content is very important in order for dry grain to store for a long period. Unfortunately, simple methods for determination of moisture content, easily usable by small scale farmers are not available. These farmers have to rely on subjective methods which are often not accurate.
MAIZE

Maize is a semi-commercial crop in Kenya. To most farmers, it is staple food while the surplus is sold for cash. Many varieties are grown depending on the location (Agro-Ecological zones)

**Harvesting:**

Maize for dry seed is harvested when the husk has turned yellow then white. The choice method for harvesting maize is cutting the whole stocks containing the cobs and assembling them in clamps, with the cob up, and then allowing further drying for a few days.

The maize in the husks are then snapped off the stock and trimmed to remove the flag leaves and the stem. The silk that might not have fallen off is also removed. During this time, the husks could also be removed.

**Post harvest handling:**

The maize could be stored in the husk. However, the cobs have to be inspected for any field infestation by insects. Storage in this form could be in well constructed cribs or granaries, from wood and serves for further drying of the kernels and the cob. The maize could also be dehusked and stored as cobs in similar structures. The cobs again should be inspected for any field infestation by insects.

Maize is threshed by machines or simple devices like mortar and pestle, or placing in a gunny bag and beating gently with a stick, or even by hand. The last method is very labour intensive but is appropriate for small operations. The method yields the best quality maize with least number of broken kernels. Broken kernels allow easy entry of insects and other pests.
The threshed maize is then winnowed to separate out the fragments of broken kernels, debris and soil. It is inspected for any possible infection/infestation from the field, dried if necessary, treated with chemical insecticides then stored.

The optimum storage moisture content for maize is 13%. The maize should therefore be dried sufficiently to this level before storage. Objective measurements of moisture content are not available to small farmers, but if the grains make a sharp sound when they are dropped on a hard surface (concrete, metallic etc) or against other grain, then the required level of moisture has probably been achieved. Farmers learn to tell this by experience.

For treatment with pesticides, use only the recommended chemicals and in recommended proportions. Information pertaining to this will be obtained from the package, the vendor of the chemicals or your local extension officer.

For transportation to the market and for storage, the kernels can be packed in gunny bags or polythene bags. They are then stored in a cool and dry place and occasionally inspected for signs of infection.

For domestic storage, any container such as baskets, pots, guards etc can be used. But these should be covered and stored in cool dry places.
BEANS

Beans like maize are also both food and cash crop of the small scale farmer. Many varieties are purely commercial

Harvesting:

Beans are ready for harvesting when they have changed from green to yellow then to dry colour. Sufficient drying can be determined by noting that a few pods split with a cracking noise on their own on a hot day.

Harvesting is by uprooting carefully the whole dry plant containing the seed pods and the dry leaves. These are then placed as clamps and further dried for 1-2 days before threshing.

In a large operation, the beans are harvested with a combine harvester which threshes them at the same time.

Post harvest handling

Threshing on small scale is done by placing the dried bean plants containing the pods on a prepared ground or a polythene sheet and gently beating them with a stick. The pods split open and release the grains. The grains are separated from the trash by simple winnowing.

The grains are sorted out to remove the blemish ones, the broken ones and those that may be infested with insects from the field

If necessary, the grains are dried. The optimum storage moisture for beans is 13-14%. Determination of sufficiency of drying can be done in a similar manner like for maize. Experience will also have shown what sufficiently dried beans look like.
The grains are treated with the recommended insecticide at the recommended levels (consult the vendor, your local extension officer or read the label).

The beans are packed in gunny bags, polythene bags (for storage and transportation) or in pots, baskets, tanks etc (for domestic storage). In all cases, the beans should be well covered to prevent insect infestation or consumption by rodents.

The beans should be stored in a cool dry place and should be inspected regularly for any signs of infestation by insects and microbial spoilage.

The beans should also be tested for development of hard to cook property (if they do cook within 60 minutes). If this seem to develop, then the beans should be brought out and dried in the sun to arrest any further development of the problem.
GREEN GRAMS
Green grams are grown in Kenya as food as well as for cash consumption. Their consumption is not as well spread as that of the beans.

Harvesting
Green grams are harvested when they mature by drying of the pods. Readiness for harvesting is checked by pressing a dry pod with fingers. If it is brittle and splits easily then the crop is ready for harvesting. Also when ready for harvesting, some pods will start splitting with a cracking sound on a hot day.

Choice method for harvesting green grams is by snapping off the dry pod from the plant using a gentle motion to avoid cracking

Post harvest handling:
Green grams pods are dried for a further 1-2 days to facilitate easy cracking
The pods are threshed like the beans, or using mortar and pestle or merely by placing in a gunny or polythene bag and beating with a stick.

Green grams are stored at optimum moisture content of 12-13%. The preceding post harvest handling practices are like for the dry beans.
SUNFLOWER

There are basically two types of sunflower seeds. The confectionary type, which is used in the confectionary industry and is of low oil content, and the oil type, which has high oil content, also referred to as the waxy type, and used for oil extraction. The sunflowers grown in Kenya are the oil-types.

Harvesting

Sunflower seed is harvested when the head containing the seeds, as well as the stalk is dry from green through yellow to white. The leaves dry to gray color. The readiness for harvesting is determined by the moisture content, which should fall between 12 and 15%. In large operations, instrumental methods are used to determine the moisture content. In small operations, the readiness for harvesting can be determined simply as follows;

1. Pick a few heads at random and test for the ease of shelling by lightly banging the heads on the palm of your hand. If the seeds fall off the head easily, then the crop is ready for harvesting.

2. Inspect the farm or plot of the crop for seed fall. If some seeds have fallen off the heads, the crop is ready for harvesting because this is an indication of easily shelled heads.

In large operations, harvesting is done with a machine that cuts the heads off and shells at the same time. In such an operation therefore, crop loss could be experienced, if harvesting was delayed due to some stalks break and the heads fall to clearance above the ground.

In small operations, harvesting of the crop is manual. The heads are stripped off the stalk gently with a sharp blade and then gently transferred to a container to avoid shelling loss.
Snapping the stem by hand could be rigorous enough to cause shelling loss. Of course picking the fallen grains could reduce the shelling loss, but this makes the harvesting operation more labor intensive than stripping.

**Post harvest Handling**

The harvested heads are shelled to release the grains. The shelling is simply carried out by agitation of the heads rigorously enough to release the seeds. Such methods as gentle banging against a surface or placing in a sack and gently banging a loose packing of heads can be used.

If the heads do not shell that easily, then this is an indication that the harvest moisture was high. The heads should then be spread out in the sun to dry for 1-2 days before shelling.

The heads are physically separated from the seeds. The seeds are winnowed to remove the chaff and then inspected to remove diseased, discolored and shattered seeds.

The crop can be delivered to the market or millers immediately after threshing. It is possible that some farmers will hold the crop temporary in storage before taking to the market. If the storage is for six months or less, then the seeds can be stored at moisture content at shelling. If the storage were to be for longer than six months, then it is advisable to dry the seeds to moisture content between 8-10%. A good indication of completeness of drying this moisture content is that some seeds will start shattering, opening up of the shell to reveal the kernel.

For storage, any container can be used. However, most appropriate is a system of storage, which keeps the seeds properly, aerated, especially if they contain the threshing moisture.
Such storage will be in gunny bags or simply the clamps on a well-prepared floor, preferably raised above the room floor level.

Storage should be in a cool dry place to avoid moisture build up in the seeds. The floor on which the gunny bags are stowed should be kept sufficiently dry.

The stored seeds should be inspected regularly for any signs of spoilage.

For delivery to the market, any appropriate package can be used.
SOYBEANS

Though grown as food, soybeans are grown as cash crop, for use in oil extraction.

Harvesting

Soybeans are harvested when the pods are dry and mature, on turning to yellow color. The leaves will turn yellow and then drop off. The stem and pods are then left until dry with the moisture content of the seeds falling to about 12%, the optimum storage moisture. Seed dryness can be checked by just cutting a few pods and moving them in the air to check the sound. Seeds can also be removed from the pods and pressed between the teeth. Finally, when some pods start splitting with cracking noise in the field on a hot day, then the crop is ready for harvesting.

Harvesting is done with a machine in large operations. The combine harvester does the harvesting and the threshing in one operation. In small operation, harvesting can be done by cutting the stem at about 3cm above the ground or by uprooting the entire plant like for common bean.

Post harvest Handling

See the common bean.

Optimum moisture for storage of soybean is about 12%
GROUND NUTS

Groundnuts or peanuts are grown extensively in some parts of the country, both for domestic consumption and for cash.

Harvesting

Groundnuts are harvested when they have matured by majority of them turning dark inside the shell. This can be done by digging a few shells, opening them and examining the seeds. Before digging out the peanut in harvesting, clip the vines and clear the weeds. This should be done about 2-3 days before digging.

Harvesting is done in large operations by using specialized machines, which do not inflict physical injury to the shells. In small operations, the groundnut shells can be dug out with an appropriate hole- the fork jembe- and the soil hollowed nicely to facilitate separation of the shells. The groundnut shells can be left on the soil for 2-3 days to dry to moisture of 18-24%. Alternatively they can be physically picked, placed in containers and dried for 2-4 days. They are then ready for shelling.

Post harvest Handling

Unshelled groundnuts can be stored in any type of container in a cool and dry place. During this time, they even undergo further drying and cool cunning. Shelling of peanuts is done by specialized machines. The kernel covered with the hull should then be dried at low temperatures e.g. the sun, to moisture content of 11-12%. This further drying also helps to develop the flavor and toughen the hull.

Small quantities can be shelled with a mortar and pestle by gentle pounding and then winnowing to separate the kernels from the trash. Shelling can also be done by hand, by
splitting open the shell to release the kernel. The kernels are then dried as usual to bring down the moisture content to 11-12%.

The shelled groundnuts are sorted to remove the blemished ones (whole or part of the hull has been removed), the undersized ones and the diseased ones.

Shelled peanuts are stored in gunny bags, in polythene bags, in pots, in baskets etc. in a cool and dry place. All storage containers should be sufficiently covered.

The peanuts are regularly inspected for any signs of mould growth.
MACADAMIA NUTS

Macadamia nuts are grown mainly as cash crop.

Harvesting of Macadamia nuts

Macadamia nuts are harvested at maturity indicated in some varieties by a splitting of the husk. Others show maturity by change of color of the husk from green to light brown.

Harvesting is by snapping of the stem. It can also be done by snipping with a sharp blade, but there is no advantage gained by using this labor intensive method.

Post harvest handling

The harvested nuts are immediately de-husked by a simple operation of applying pressure on the fresh and soft husk until it separates from the nutshell. This is followed by physical separation of the nut from the mash. They are then sorted out.

The shelled nuts are dried lightly to get rid of the wetness from the surface. Too much drying reduces the sellable nut weight.

The shelled nuts are placed in bags, boxes, tins, baskets etc. for delivery to the market.

The nuts have to be stored before taking to the market, and then the storage should be done in a cool and dry place. The shell is hard enough to prevent penetration by pests.