

4. Quality Management of Individual Produce



4. QUALITY MANAGEMENT OF INDIVIDUAL PRODUCE

This section consists of a guide to quality management during and after harvest of some of the more important produce grown in the highlands of PNG. Each section deals with a specific type of produce, arranged in alphabetical order.

4.1 Asparagus

Asparagus is a crop that can be grown all year round. It looks like bamboo shoots but the shoots are smaller in size. The shoots are called spears and they are harvested (and eaten) just before the leaves open. Asparagus is good for the health as it is a good source of vitamin A, several of the B vitamins, vitamin C, fibre and potassium. It may help to reduce skin and kidney disorders.

4.1.1 Maturity and harvesting

Do not harvest the spears before the recommended time because the roots will not be strong enough; some will die and yields will be low. The first harvest should take place 7–9 months after transplanting from the nursery. At this time remove all the ferns (leaves) and 3–5 days later the spears will emerge. Harvest the spears when they are 25–30 cm long and the leaves are tight and unopened. Do not harvest earlier than this. After the first harvest, apply a matchbox full of NPK fertiliser to each plant and wait 4 months before the second harvest. Repeat this process, i.e. fertilise and allow to rest, prior to the third and subsequent harvests. It is important to include the 4-month resting period between harvests to allow the asparagus to heal properly. Continuous harvesting without a rest period will cause the plant to die.

Harvest the spears by inserting a long-bladed knife close to the base of the shoot and removing it with a sloping cut. Harvesting should be done during the cool hours of the day, either early morning or late afternoon.

Knives must be kept sharp and clean at all times to prevent spreading virus diseases from plant to plant.

Quality requirements for market:

- Must be 20–25 cm long and round.
- Must be soft, not too strong and fibrous.
- Should break easily when bent without forming a U-shape.
- Should have tightly closed tips and leaves.
- Should be straight, either pale green or white or sometimes slightly purple.

4.1.2 Postharvest handling

Precooling

After harvesting the asparagus spears put them in a string bag (bilum) and immediately immerse them in a creek or river (or moving cold water). Leave the asparagus in the moving cold water for about an hour or two. Make sure that the water is clean and drinkable.

Sorting, grading and bunching

Asparagus spears that are broken, short or damaged should be removed. The spears may be graded according to market requirements. Only those that meet the quality requirements are bunched using a rope or rubber band. Bunching asparagus makes it easier to handle and also avoids damage. A bunch should contain 7–10 asparagus spears depending on the size.

Packing and weighing

Asparagus spears break easily so pack them in a small carton carefully and neatly. They can be packed either in a standing position or a sleeping position (Figure 4.1). A carton of asparagus should hold 6–10 kg.



Figure 4.1: Asparagus packed neatly in a sleeping position.

4.1.3 Storage

Asparagus is a highly perishable crop and ideally should be stored under very cold temperatures (0–4 °C) and very high humidity (95–100%). Conditions outside these ranges could result in deterioration of the shoots. If cool storage is not available, asparagus should be sold as soon after harvest as possible. Farmers selling in the local market should sell the same day as the asparagus is harvested.

Asparagus is an ethylene-sensitive product so keep it away from ethylene-producing produce during storage and transportation.

4.1.4 Transportation

During transportation, handle the produce with care. Do not throw the cartons of asparagus during loading and unloading, but lift them and put them down carefully. Do not allow anyone to sit on top of the cartons or allow anything heavy to be placed on them. Do not stack the cartons more than four layers high. Transport asparagus in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.2 Broccoli

Broccoli belongs to the same family group as English cabbage. It is leafy and produces a flower head, which is the part that is eaten. The flower head is made up of many small unopened flowers. Broccoli is good for the health as it contains vitamins C and E and minerals like iron and potassium. Broccoli may help to guard against cancer.

4.2.1 Maturity and harvesting

Broccoli is ready for harvest when the head is a good size (12–18 cm wide) and when the small flowers are green in colour in a tight compact head. If the flowers open and are yellow in colour then it is too late and the broccoli is overmature.

The flower heads can be cut with a sharp knife and trimmed in the field, or snapped off by hand and subsequently trimmed. See Figure 3.2, where the broccoli head is pushed slightly to one side and the main stem cut through with a sharp knife. It is important to leave enough leaf to cover the head to offer protection during handling and transportation. Broccoli should be harvested during the cool hours of the day, in the early mornings or late afternoons.

Quality requirements for market:

- Must have a head that is tight with no hollow stalk.
- Must be of a good average size—not too big or small (12–18 cm wide).
- Should have green unopened flowers on the head (Figure 4.2).
- Must be free from damage by insects or diseases.



Figure 4.2: Good-quality broccoli.

4.2.2 Postharvest handling

Precooling

It is a good idea to precool broccoli immediately after harvest. Precooling removes field heat that would otherwise shorten the shelf life of the crop. When produce is precooled, the temperature of the crop is brought down quickly. The simplest and quickest method of precooling broccoli is to use iced water in a bucket, immersing the broccoli for about 1 hour (Figure 4.3). Alternatively, the broccoli can be put in a string bag (bilum) and immersed in a creek or river (or moving cold water) for an hour or two. Make sure this water is clean and drinkable.



Figure 4.3: Precooling broccoli using iced water.

Trimming

Trim off the leaves but leave two or three leaves to offer protection to the heads during handling and transportation.

Sorting and grading

Remove any diseased and pest-damaged plants. The broccoli may be graded into different head sizes according to market requirements.

Packing

It is important to pack broccoli tightly so that the heads do not move freely and cause damage. Use good cartons that can hold up to 10 kg each (Figure 4.4). Do not use bags or sacks.

For long-distance marketing it is preferable to pack the broccoli with ice in a carton with a plastic liner (see Figure 3.9).

4.2.3 Storage

Broccoli is a highly perishable crop and may not last for more than 1 or 2 days when kept under unfavourable conditions. At 0–4 °C and high humidity, broccoli can be stored for up to 2–3 weeks. Keep broccoli away from ethylene producers during storage and transportation. Ethylene increases respiration in broccoli, which in turn reduces the shelf life of the crop.



Figure 4.4: Well-packed broccoli heads in a carton.

4.2.4 Transportation

During transportation it is important to handle the produce with care. Do not throw the cartons of broccoli during loading and unloading, but lift them and put them down carefully. Do not allow anyone to sit on top of the cartons or allow anything heavy to be placed on them. Transport broccoli in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.3 Cabbage, English

English cabbage has a big, round, strong head that is made up of dark green fleshy leaves tightly bound together. The inside leaves are white. The dark green leaves are high in vitamin C and iron. It may help people suffering from anaemia.

4.3.1 Maturity and harvesting

After transplanting out to the main garden, the cabbages will be ready in 2 months on the lowlands/coast and 3 months in the highlands. The cabbage head must be firm and tight when it is ready to be harvested. Press the head gently to check for firmness (Figure 4.5). If left too long the head will break or become loose.

During harvesting slightly push the head to one side and cut the stem with a clean heavy knife once. Make sure that the heads are not bruised or severed. Harvesting should be done in the cool hours of the day, either late in the afternoon or early in the morning. Leave two or three outer leaves to



Figure 4.5: Check the heads of cabbage for firmness.

offer protection to the heads. Do not remove all the green leaves from the cabbage, because if it is all white it will not look attractive to the buyer.

Quality requirements for market:

- the cabbage head must be of a good size
- the head must be tightly bound and firm
- the head must not show signs of insect or disease damage.

Formal markets prefer to buy cabbages like the one in Figure 4.6.



Figure 4.6: Good-quality cabbage.

4.3.2 Postharvest handling

Precooling

After harvest the cabbages may be put in a cool room for precooling. However, this is not essential since English cabbages are not highly perishable.

Cleaning and trimming

Dirt adhering to the base of the cabbage should be removed. Dry leaves should be trimmed, leaving enough leaves to protect the head.

Packing

The cabbages can be packed either in coffee bags or cartons with holes to allow air to flow through and keep them cool and dry. Do not use flour or stockfeed bags without air holes in the sides as the cabbages will sweat and start to rot. A bag of cabbage may weigh up to 60 kg. Be sure to carry or handle the packed bags with care, and don't sit on them or stack them too high as the cabbages can be damaged easily (Figure 4.7).

4.3.3 Storage

Cabbages can be stored up to 3 months under favourable conditions of 0–4 °C with high humidity. Under highlands conditions (25–27 °C and 60–70% relative humidity) they can be stored for up to 1 week. It is advisable to keep the cabbages under cool conditions for longer storage and away from ethylene producers during storage and transportation. Ethylene increases respiration in cabbages, which in turn reduces the shelf life of the crop.



Figure 4.7: Cabbages well-packed in a coffee bag (left). What is wrong in the photo on the right?

4.3.4 Transportation

During transportation it is advisable to handle the produce with care. Do not throw the bags or cartons of cabbages during loading and unloading, but lift them and put them down carefully. Since a bag of cabbages weighs about 50–60 kg it would be a good idea to have two people carry one bag at a time during loading and unloading. Do not allow anyone to sit on top of the bags or cartons or allow anything heavy to be placed on them. Transport cabbages in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.4 Capsicum

Capsicum is a pepper that is not hot like other peppers but is sweet. It is a fruit vegetable that is usually bell shaped and is used in many dishes to enhance and provide flavour. Green capsicums contain vitamin C and powerful antioxidants, which may protect the body against cancer and heart disease.

4.4.1 Maturity and harvesting

The fruit is ready for harvest when it is a good size and firm, and the skin is clear and shiny. Most are harvested when they are green, but if left longer in the garden some of the fruit will turn red.

Capsicum can be picked by hand, but this needs to be done with care since it has a fleshy stem that can be easily broken. This may cause damage to the plant or the fruit which can lead to infections. It is better to use a clean sharp knife or secateurs and make a clean cut on the stalk just before the fruit.

Quality requirements for market (Figure 4.8):

- Must be a good size (not too small or too big).
- Must have clean skin with no marks, spots or discolouration.
- Skin must be firm with no bruising.
- Must be free from pest and disease damage.



Figure 4.8: Good-quality capsicums.

4.4.2 Postharvest handling

Precooling

It is a good idea to remove field heat immediately after harvest by putting capsicums in a basket and dipping them in cool running water for an hour. Fans can also be used to precool capsicums where electricity is available.



Figure 4.9: Capsicums packed in a collapsible plastic crate.

Cleaning, sorting and grading

All damaged, malformed and bruised capsicums should be removed. Those with dirt adhering to their surface can be cleaned by wiping the surface with a moist soft cloth. The capsicums may be graded into same size and colour lots according to market requirements. Capsicums like those shown in Figure 1.1 should be removed during sorting.

Packing

Pack capsicums in good packaging material such as cartons or plastic crates. Never pack them in bags or bilums as they will break easily. A carton of capsicums should hold about 10 kg. (Figures 3.7, 4.8 and 4.9).

4.4.3 Storage

Capsicums can be stored in a cool room at a temperature of 7–10 °C for up to 3 weeks. For storage purposes, capsicums should be of good quality because quality will decline during storage. Since produce in storage will be competing with newly harvested produce, it is a good idea to try to minimise the amount of time in storage before selling.

4.4.4 Transportation

During transportation it is advisable to handle the produce with care. Do not throw the cartons of capsicums during loading and unloading, but lift them and put them down carefully. Do not allow anyone to sit on top of the cartons or allow anything heavy to be placed on them. Transport capsicums in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.5 Carrots

Carrots belong to the same family as parsley and celery. The edible part of the carrot is the orange coloured root that grows in the soil. Carrots are good for the health as they are high in Vitamin A, which may be good for the eyesight, the skin and the heart, and may also help guard against cancer.

4.5.1 Maturity and harvesting

Carrots are ready for harvest 10–15 weeks after they have been planted. Check the size of the carrots (roots) in the garden—if they are about as long as an average adult human hand, they are ready for harvest.

Carrots are loosened from the soil by inserting a digging tool at an angle and levering it upwards. The roots must be lifted carefully to avoid damage, and shaken to free the soil. The carrots can also be pulled from the soil if they are grown on loose soil. Harvest carrots during the cool hours of the day, either late in the afternoon or early in the morning.

Quality requirements for the market:

- Must be of a good size, about the length of a man's palm (Figure 4.10) and not too big or too small.
- Must not be broken, twisted or have a green colour around the top.
- Must not be dry and rubbery.



Figure 4.10: A good-sized quality carrot.



Figure 4.11: These carrots have been washed and trimmed.

4.5.2 Postharvest handling

Precooling

Carrots are a less perishable crop and may not need precooling.

Cleaning and trimming, sorting and grading

Carrots usually have soil adhered to their surface so it is a good idea to wash them (Figure 3.5) and trim their leaves (Figure 4.11). The carrots are then sorted, removing the deformed and other bad ones (Figures 1.1 and 3.6), and may be graded according to market requirements, especially by size (Figure 3.7).



Figure 4.12: Carrots being packed into a carton.

Packing

Carrots should be packed in cartons (Figure 4.12), special carrot bags or net bags. Pack the carrots neatly and properly so they do not break. A carton or bag should contain 15–20 kg. If you use flour or stockfeed

bags make sure they have air holes in the sides, otherwise the carrots will sweat and start to rot.

4.5.3 Storage

Mature carrots can be stored for a longer period (about 5 months) if kept under favourable conditions of 0–4 °C with high humidity. Immature carrots under the same conditions can be kept for about 1 month.

Carrots intended for storage should be of good quality (i.e. first remove any bruised, damaged and other unwanted ones). Keep carrots away from ethylene-producing produce like ripe tomatoes as this will make the carrots taste bitter.

4.5.4 Transportation

During transportation it is advisable to handle the produce with care because carrots break easily. Do not throw the cartons or bags during loading and unloading, but lift them carefully and put them down carefully. Do not allow anyone to sit on top of the bags or cartons of carrots or allow anything heavy to be placed on them. Transport carrots in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.6 Cauliflower

Cauliflower belongs to the same family as cabbage and broccoli. It has large broad leaves with a white flower head between the leaves. This crop is a good source of vitamin C and may help guard against lung cancer, heart disease, and digestive and kidney disorders.

4.6.1 Maturity and harvesting

Cauliflower is ready for harvest when the head is of a good size (12–18 cm wide), white in colour, tight and compact. When it is ready the leaves covering the head open up, exposing the white head. When the small flower head first appears, cover it with leaves to prevent damage by the sun. Sunlight makes the head turn a yellow colour. When the cauliflower head starts to open it is overmature.

Cauliflower can be cut with a sharp knife and trimmed in the field. Slightly push the plant to one side and slash the main stem once with a clean heavy knife. During the harvesting operation make sure that the heads are not damaged or bruised. Harvesting should be done in the cool hours of the day, either late in the afternoon or early in the morning.

Quality requirements for market (Figure 4.13):

- Should have a white flower head with no marks or spots on it.
- Head must be tight and of a good size.
- Head must still have some leaves to cover it.

4.6.2 Postharvest handling

Precooling

It is a good idea to precool cauliflower immediately after harvest. The simplest and quickest method of precooling is to use iced water. If you have access to ice, break it up, put it in a bucket of water and immerse the cauliflowers. Alternatively, cauliflowers can be put in a string bag (bilum) and immersed in moving cold water (such as a creek or river) for an hour or two. Make sure the moving cold water is clean and drinkable.

Trimming

Trim the head, leaving two or three leaves covering the head to offer protection during handling and transportation (Figure 4.13).

Packing

Pack the cauliflower properly in cartons with holes for airflow. Do not leave spaces between them, so as to avoid movement that will cause damage during transportation (Figure 3.9).

4.6.3 Storage

Cauliflower is a perishable crop. When kept under optimum conditions of 0–4 °C with high humidity, the crop can last for about 3 weeks. For storage purposes collect only the good quality ones. Cauliflower is sensitive to ethylene so keep the crop away from ethylene producers during storage and transportation.



Figure 4.13: Good-quality cauliflower.

4.6.4 Transportation

During transportation it is advisable to handle the produce with care because the heads can be easily damaged. Do not throw the cartons of cauliflower during loading and unloading, but lift them carefully and put them down carefully. Do not allow anyone to sit on top of the cartons or allow anything heavy to be placed on them. Transport cauliflower in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.7 Cucumber

The cucumber is a trailing or climbing plant with hairy, angular stems. It is a popular crop that has been grown for many more years than other introduced produce. It is an important fruit vegetable in the same family group as melons.

4.7.1 Maturity and harvesting

The crop is ready for harvest 60–70 days after planting. Harvest cucumbers when the fruit has grown to a good size but is still young and the seeds inside soft. Always check the garden to make sure the fruit do not become too big and overmature. Overmature fruits turn brownish yellow in colour. Buyers generally prefer green coloured cucumbers about 15–20 cm long. However, some wholesale buyers may prefer yellow or white cucumbers. The fruits are picked by hand by cutting or clipping away the fruit to avoid injury to the vine. Harvest fruit during the cool hours of the day, either early in the morning, late in the afternoon or on a dull day. Make sure that the fruit is not damaged or bruised.



Figure 4.14: A good-sized cucumber.

Quality requirements for market:

- Should be of a good size and shape (Figure 4.14).
- Must show no signs of rotting or insect damage.
- Must be the colour required by the buyer.

4.7.2 Postharvest handling

Precooling

Cucumbers may be pre-cooled by putting them in a cool room where it is well ventilated. Alternatively, they may be hydro-cooled by putting them in a basket and dipping them in cool, moving water (such as a creek or river). However, precooling is not essential for cucumbers; in fact, cucumbers are sensitive to chilling injury at temperatures less than 10 °C.



Figure 4.15: Cucumbers being packed in a lined carton.

Grading

Cucumbers may be graded into same sizes and colours according to market requirements.

Packing

Pack cucumbers neatly in a good carton, preferably of the same size and colour in each carton (Figure 4.15). A carton of cucumbers should hold about 10 kg. Do not pack them in a flour or net bag as they can be easily damaged.

4.7.3 Storage

The optimum storage temperature for cucumbers is 10–13 °C. This crop is sensitive to temperature extremes. Temperatures less than 10 °C can cause chilling injury, while temperatures above 16 °C can cause yellowing of the fruit. Cucumbers are sensitive to ethylene so keep them away from ethylene-producing produce like ripe tomatoes and ripe avocados.

4.7.4 Transportation

During transportation it is advisable to handle the produce with care because the fruits can be easily broken and damaged. Do not throw the cartons of cucumber during loading and unloading, but lift them carefully and put them down carefully. Do not allow anyone to sit on top of the cartons or allow anything heavy to be placed on them. Transport cucumber in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.8 Lettuce

The lettuce grown and sold in PNG is head lettuce, which has green leaves with a firm round head. Lettuce may help with nervous, digestive and sleep disorders.

4.8.1 Maturity and harvesting

Lettuce is ready for harvest at 7–12 weeks after planting. At this time the lettuce head will be tight, strong and firm. Before harvesting press the head gently for firmness (Figure 4.16).

To harvest, slightly push the head to one side and slash the main stem once with a clean, heavy, sharp knife. Make sure that the heads are not bruised or damaged as this will lead to a loss in quality. Harvesting should be done in the late afternoon or early in the morning. Do not harvest the lettuce when it is wet as it will heat up quickly and give rise to rotting.



Figure 4.16: Check the lettuce head for firmness and tightness before harvest.

Quality requirements for market:

- should have a strong, tight head
- the head must be of a good size
- the head must not show signs of insect or disease damage.

4.8.2 Postharvest handling

Precooling

Lettuce may be cooled by placing it in a well-ventilated cool room (shed) which should have a temperature 10–15 °C less than the outside temperature. If electricity is available then forced-air cooling would be helpful. Have a fan in a ventilated room/shed blowing across the lettuce.

Trimming and sorting

Leaves that are dry (brown) at the base of the lettuce head should be trimmed off. Those that are damaged or bruised should also be removed.

Packing

Always pack the lettuce in a carton (preferably a special lettuce carton) as shown in Figure 4.17. Pack the lettuce neatly and tightly so that unnecessary movement is restricted during handling and transportation. This will avoid bruising of the heads. Do not pack the lettuce in bags (bilums) as this will cause the leaves to break and the heads to become squeezed (Figures 4.17).

4.8.3 Storage

Lettuce is a perishable crop that needs to be stored under low temperature and high humidity conditions. When stored at the optimum temperature of 0–4 °C and relative humidity of 95–100%, lettuce can be kept for up to 3 weeks. For storage purposes select only good quality lettuce but remember that stored lettuce is never as good as fresh lettuce. On the market stored lettuce will compete with fresh lettuce, so it is advisable to have lettuce stored for only short periods (up to 1 week). Lettuce is sensitive to ethylene so keep it away from ethylene producers during storage and transportation.

4.8.4 Transportation

During transportation it is advisable to handle the produce with care because the heads can be easily damaged. Do not throw the cartons of lettuce during loading and unloading, but lift them carefully and put them down carefully. Do not allow anyone to sit on top of the cartons or allow anything heavy to be placed on them. Transport lettuce in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.



Figure 4.17: Lettuce packed in a carton (top) is well protected, unlike in the bilum (bottom).



Figure 4.18: A good-quality bulb onion (45–60 mm diameter).

4.9 Onion, bulb

Bulb onions of different types are grown worldwide for the flavour they contribute to food. They are also commonly regarded as having medicinal properties. In many countries onions are used in the immature green state. In others, where the crop is seasonal, onions are grown that can be stored in a dry state.

4.9.1 Maturity and harvesting

When the bulbs developing from the leaf bases of bulb onions are fully formed, the leafy green tops begin to yellow and eventually collapse to a point a little above the top of the bulb, leaving an upright short neck. When the tops 'go down' in this way the bulbs are ready for harvesting. Because not all the onions in a crop mature at the same time, large-scale commercial growers harvest them when about half the tops have gone down.

Small-scale growers can, if they wish, harvest their crops progressively as the tops go down, especially if they intend to store the dry bulbs for sale or use at a later date. Since onion bulbs are normally formed at the soil surface, it is sometimes possible in sandy soils to pull the mature bulbs out by hand. Where conditions make hand-pulling impossible, harvesting is done by loosening the bulbs with a fork or hoe before lifting them.

It is a good idea to pull each bulb up gently and rest it on its side in the field, exposing the base and the roots to the sun so they can dry out. The bulbs can be left in the field for 3–4 days, turning them to make sure that all the basal parts are exposed to the sun.

It is important that planting of bulb onions should be well planned so that the crops are ready for harvest during dry seasons. If the crops are ready for harvest during wet seasons, curing may not be effective and will result in the crops decaying and losing their quality.

Quality requirements for market:

- must be of a good size (45–60 mm diameter) (Figure 4.18)
- must have a strong, dry outside skin layer with no signs of rotting
- must not be growing new shoots.

4.9.2 Postharvest handling

Sorting

All damaged or decaying onion bulbs should be discarded. Onions with thick necks should be put aside for immediate use because they will not store well.

Curing

Curing is a drying process intended to dry off the necks and outer scale leaves of the bulbs to prevent loss of moisture and attack by decay during storage. The essentials for curing are heat and good ventilation, preferably with low humidity. This dries out the neck and the two or three outer layers of the bulb. The outermost layer, which may be contaminated with soil, usually falls away easily when the bulbs are cured, exposing the dry under-layer which should have an attractive appearance. In dry, sunny weather the harvested crop can be cured by leaving it in windows in the field for a few days until the tops are dry. Where the harvested bulbs are exposed to high-intensity sunlight (e.g. at high altitudes in the tropics), the windrows should be made so that the green tops cover the bulbs to protect them from sunburn.

A length (2.5 cm) of the leaf stalk and some roots should be left attached to the bulbs, and not removed completely. If the bulbs cannot be dried in the field, they can be collected in trays, which are then stacked in a warm covered area with good ventilation (see Figure 3.15). In cool, damp climates the bulbs are cured in bulk-ventilated stores, where they are dried with artificial heat blown through the bulk at a temperature of 30 °C. The storage conditions suitable for curing onions are given in the table below. Onions can also be cured by tying the tops of the bulbs in bunches and hanging them on a horizontal pole in a well-ventilated situation (Figure 4.19).

Temperature (°C)	Humidity (%)	Duration (days)
30–45	60–75	14–21



Figure 4.19: Bulb onions being cured inside on a horizontal pole.

Grading

Market requirements will determine whether onions need to be size graded or not. Retailers in local markets will normally do their own grading when making up lots for sale. If bulb onions are to be made up into strings for storage or sale, it is an advantage to separate them into a more or less uniform size on any string. This makes the stringing operation easier and gives a better appearance to the finished product.

Packing

For bulk marketing the tops of onions are removed when they are thoroughly cured and the necks are quite dry. For small-scale marketing onions may be made up into strings weighing 5–10 kg. This is, however, a labour-intensive operation suited only to small-scale production using family labour. It is not cost-effective on a commercial scale. For larger-scale marketing the onions should be packed into net bags so that the produce stays cool and dry. These bags can weigh about 20 kg (see Figure 3.9).

4.9.3 Storage

The first key to successful storage of dry bulb onions is choosing the right seed variety to plant. It should have a long dormancy period and be able to form a strong outer skin when fully cured. After harvest and curing, bulbs put into storage should be disease free. The most important storage disease is neck rot, which is controlled by dusting the onion seed before planting with a chemical called benomyl fungicide at the rate of 1 g active material per kilogram of seed.

The storage environment must be dry and well ventilated. Optimum (high-temperature) storage is between 25 °C and 30 °C. Outside this range the stored onions will sprout and, if the atmosphere is damp, will develop roots. Onions can also be stored in bulk-insulated stores, with fans for cooling using cold night air. This method is used where large tonnages are stored. Small-scale growers can use naturally ventilated stores made from local materials, where the onions can be stacked in trays or in layers on slatted shelves.

Where small amounts are to be stored, stringing onions in 5 kg or 10 kg lots and hanging the strings in a well-ventilated dry location is a very effective storage method. The tops of the onions should not be cut off, but left so that they can be fixed to a double string by weaving the dried top of each onion through the strings in a figure-8 fashion. Alternatively, onions can be tied by their dried tops in bunches and hung on a horizontal line or pole in the shade.

4.9.4 Transportation

During transportation it is advisable to handle the produce with care because the flesh can be easily damaged. Do not throw the bags of bulb onions during loading and unloading, but lift them carefully and put them down carefully. Do not allow anyone to sit on top of the bags or allow anything heavy to be placed on them. Transport bulb onions in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.10 Potato

These are also called Irish or white potatoes. Although most of the world's potato production is in temperate regions, the crop is becoming more important as a food source in the tropics and subtropics.

4.10.1 Maturity and harvesting

Potatoes are ready for harvest when the stems and leaves dry up and die, about 3–5 months after planting. However, potatoes can be harvested for immediate consumption in an immature state, usually from the time they reach full flowering. At this stage the skin is thin and soft, and the potatoes cannot be stored.

Potatoes which are to be sold but which may need to be stored should not be harvested until at least 2–3 weeks after the plant tops have died off, by which time the skin of the tubers is fully developed and they are mature. They are then less susceptible to damage than immature potatoes. After harvest the potatoes should be cured for about 2 weeks.

Potato harvesting is best done when the soil is slightly moist. Where they are produced on a small scale, harvesting is carried out with handtools. The tubers must be lifted carefully to avoid damage, and shaken free of soil. They are left to dry in the field, after which they are collected in field containers and placed in a cool shady place. Potatoes for food must not be exposed to the light for more than a few hours after harvest or they will turn green, develop an unpleasant taste and may become toxic.



Figure 4.20: Rub the potato with a thumb to see if it is ready for harvest. A strong skin means it is ready, a soft skin that easily rubs away means it is not ready.

To determine if the potato is ready for commercial harvest, the skin should be rubbed with a thumb as shown in Figure 4.20. If the skin is strong, it is ready for harvest, but if it is easily rubbed away then leave the potatoes in the ground for a little while longer.

Quality requirements for market (Figure 4.21):

- Must be dry with a strong outer skin.
- Must be free of soil or dirt.
- Must have no insect or disease damage.
- Must not be green in colour.
- Must be the size of an adult fist.

4.10.2 Postharvest handling

Selection and grading

All potatoes showing greening decay or severe damage owing to harvesting or pest attack should be discarded at harvest. Immature tubers and those wetted by rain or showing minor damage should be put aside for immediate consumption. Potatoes to be stored for food or seed should be fully mature and free from any visible damage or decay. Size-grading requirements will depend on market demand. In most cases there will only be standards for minimum size, but sometimes also for maximum size. Local specialists should be consulted on the subject.



Figure 4.21: Potatoes preferred by markets are free of dirt and the size of an adult fist.

Curing

Potatoes to be stored need curing to repair any skin damage that may be present (Figure 3.14). Curing is best carried out after the potatoes have been placed in store. It involves reducing ventilation to allow an increase in temperature and a build-up of humidity, which are needed to promote curing. The potatoes should be covered with straw and the store well insulated to prevent the condensation of free water on the potatoes. The storage conditions suitable for curing potatoes are given in the table below. The higher the temperature (in the given range), the shorter the time needed for curing. At the end of the curing time full ventilation should be restored to the store.

Temperature (°C)	Humidity (%)	Duration (days)
15–20	85–90	5–15

Packing

Although baskets or wooden boxes may be used to market potatoes, bags are cheaper and more commonly used. They are usually of 50 kg capacity and need to provide good ventilation. Bags include coffee bags, net bags and flour bags (Figure 4.22). The coffee bag is best because:

- It allows air to pass through, keeping the potatoes inside cool.
- It prevents light from entering the bag and turning the potatoes green.

When using net bags to pack potatoes, do not leave them in the sunlight or else the potatoes will turn green. When using flour bags, make holes in the sides for airflow, otherwise the potatoes will sweat and start to rot.



Figure 4.22: From left to right, potatoes packed in a coffee bag, flour bags and net bag.

4.10.3 Storage

Only sound potatoes with no apparent damage or decay should be stored. Potatoes to be used for food or for processing must be kept in the dark to prevent greening. Seed potatoes are stored in diffuse light to promote the development of several strong shoots on each tuber.

On-farm storage can be carried out in low-cost structures employing local skills and using local materials. Where climatic conditions are suitable, potatoes can be left in the field for some weeks after maturity. However, it is generally preferable to collect them for storage in a structure where some measure of control over the storage conditions can be achieved.

Low-cost, small-scale pole and thatch stores holding up to 2 tonnes of potatoes can be constructed in the field. They are particularly suitable for seed potatoes to be held in diffuse light conditions. Potatoes are held in these stores in open trays or on well-ventilated shelves.

Existing buildings may sometimes be modified for storing up to 20 tonnes of potatoes under natural or assisted ventilation. Whatever the type of

store, it is necessary to keep the potatoes dry and as cool as possible by having an insulated structure with good ventilation.

4.10.4 Transportation

During transportation it is advisable to handle the produce with care because the flesh can be easily damaged. Do not throw the bags of potatoes during loading and unloading, but lift them carefully and put them down carefully. Do not allow anyone to sit on top of the bags of potatoes or allow anything heavy to be placed on them. Transport potatoes in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

4.11 Sweet potato (kukau)

Kukau is an important crop in PNG. There are many varieties grown, especially in the highlands. It is a good source of carbohydrate and vitamins A and C.

4.11.1 Maturity and harvesting

In the highlands kukau is ready for harvest 9–12 months after planting, and in the coastal lowlands 4–6 months after planting. When ready for harvest, leaves may start to dry.

Harvesting kukau is easier if grown on raised beds or mounds. The digging tool can be pushed into the soil under the tubers, which can then be levered upwards, loosening the soil and decreasing the possibility of damage to the crop.

Quality requirements for market (Figure 4.23):

- Must be of a good size.
- Must be fresh.
- Must be free from disease or insect damage.
- The tuber skin must be clean.



Figure 4.23: Kukau with good size and shape and free from blemishes (suitable for supermarkets).

4.11.2 Postharvest handling

Sorting

Sorting is an activity whereby damaged, bruised, diseased, pest-damaged and deformed kaukau is removed. Figures 4.24 and 1.1 show some examples of kaukau that should be removed from commercial supply.

Cleaning

Most markets require clean produce, so kaukau should be brushed dry using a dry cloth, or washed and then dried to remove excess moisture. Washing plays an important role in removing dirt and other residues (from sprays and dust) and also freshens the produce, making it appealing to the customer.



Curing

Curing is carried out to heal wounds encountered during harvesting and also to harden the skin. It is also effective in reducing decay and water loss during storage or transit. Curing may be done in the field or in curing rooms. The conditions for curing kaukau are summarised in the following table.



Figure 4.24: During sorting, kaukau like these are removed. What can you say about them?

Temperature (°C)	Humidity (%)	Duration (days)
30–32	85–90	4–7



Figure 4.25: Oversized (left) and undersized (right) kaukau. Oversized kaukau are suitable for the institutional markets, while undersized kaukau are more suited to the open market.

Grading

Grading involves sorting the kaukau tubers to ensure uniform size, length, colour and firmness. Grading can be profitable because different customers prefer different grades of kaukau. For example, the tubers in Figures 4.23 and 4.25 could be usefully graded on the basis of size. The tuber in Figure 4.23 is most suited to the supermarkets, while the oversized tuber in Figure 4.25 is most suited to the institutional markets (e.g. hotels, prisons and universities) and the undersized one to the open market.

Packing

Kaukau is packed into bags, cartons or boxes. It is better to pack it into hessian/coffee bags and net bags since they have holes that allow for ventilation (Figure 4.26). It is not a good idea to pack kaukau into flour or stockfeed bags unless holes are made in the sides, as this leads to heat accumulation and eventually to sweating and rotting of the tubers (Figure 4.27). One bag can hold 50 kg of kaukau.

Overpacking and underpacking should be discouraged as either practice greatly increases the risk of damage during storage or transport. When underpacked the kaukau tend to move within the bag, which leads to excessive damage. When overpacked the bags become very heavy and bulge, which can increase the damage from rough handling (e.g. dropping from a height) or breakage of the bag. As with most produce, kaukau should be tightly packed but not overpacked.



Figure 4.26: The coffee bag is good for packing kaukau.



Figure 4.27: The net bag (left) is suitable for packing kaukau but the flour/stockfeed bag without air holes (right) is not.

4.11.3 Storage

Kaukau are often stored after curing and before preparation for marketing. They can be stored for longer periods provided that the storage conditions are right (i.e. ventilated storage in cellars or warehouses or mechanical refrigeration).

Note that, during storage, kaukau should be kept well away from ethylene-producing produce since this gas can cause discolouration and an unpleasant flavour.

4.11.4 Transportation

Several factors reduce quality during transportation including bruising, rough handling, high transit temperature (especially if field heat is not removed before loading), poor or no packaging, and bad roads. Bruising is increased when kaukau is handled repeatedly. Vibration during transport may also cause bruising, and rough handling during loading and unloading of trucks may increase the loss of quality. Heavy piling of bags of produce one on top of the other (deep piling) can cause crushing and heat build-up due to respiration of the produce. High temperature usually develops in transport vehicles due to inadequate ventilation in addition to the high outside temperature and high solar radiation common in the tropics. It is therefore important that kaukau is kept cool with good ventilation as this helps to maintain the quality and reduce wilting and weight loss. Handle the bags with care during transport to prevent bruising and wounding of the kaukau, as this will also cause rot. Do not sit, or place animals or heavy objects, on top of the kaukau bags. Avoid these problems by using crates that can be stacked neatly. Transport kaukau in the early morning, late afternoon or night when it is cool. It is a good idea to use cool containers for long-distance market transportation.

