Special postharvest treatments to horticultural produce

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Several basic treatments are applied to fresh produce. In addition, some fresh produce may require special treatments in order to slow down their rate of deterioration and minimize losses. The crops involved are for the most part those which are seasonal and subjected to long-term storage, or which are highly perishable and are transported over long distances to market. Some of the special treatments, such as hot water dipping of mango and degreening of citrus, curing of potatoes and onions, are often used just to make the produce acceptable for a given market rather than for any great need to prevent their spoilage.

These special treatments may be applied before, during or after packing of the produce and are supplements to the normal and basic practices of grading, selecting, cleaning, and temperature and humidity management and should never be considered as replacements for such practices. Fruits, because of their generally higher value, seasonality and greater perishability are the most common commodities to be given special post-harvest treatments. Root crops are often 'cured' to prolong their storage life and minimise losses, while crops such as onions and potatoes may also be treated with sprout suppressants prior to long-term storage. Fungicides are now in widespread use for decay control in many fruits, vegetables and root crops. These and other treatments are described in more detail below.

Ripening and degreening of fruits

Oranges and grapefruit grown in different parts of world remain green, partly green, or will reach full colouration depending on various environmental factors but especially night-time temperatures. Regardless of colour, the local markets recognize that the fruits are perfectly good to eat and consumers worry more about fullness of flavour, juiciness and sweetness than appearance of the fruits. The export markets demand full-coloured fruits and so a degreening process is necessary.

Degreening is the process where the green chlorophyll pigments in the peel are broken down and the yellow and orange xanthophyll and carotenoid pigments are formed. In citrus, this natural process is stimulated by exposing the fruits to 10 to 20 parts per million (ppm) of ethylene gas under controlled conditions of temperature, humidity and ventilation, in special degreening rooms. Degreening is generally considered uneconomic unless large quantities of fruit can be treated at one time.

Ripening of fruits is a perfectly natural and highly desirable phenomenon leading to increased sweetness, flavour development and softening of the edible tissue. However, ripening of certain fruits presents a dilemma to the export industry because the very act of ripening clearly marks the onset of senescence rapidly leading to decay and spoilage. The so called 'climacteric' fruits such as mango, banana, and avocado are harvested and shipped for export in the green state while still hard and capable of surviving the physical handling with minimum damage and

spoilage during transit. The transformation from green unripe to yellow ripe bananas is achieved by stacking the boxed fruit in special airtight rooms where they are exposed to 1,000 ppm of ethylene gas under controlled temperature and high humidity.

In the tropics, banana ripening is traditionally achieved by harvesting of fuller fruit and simply waiting for it to ripen at ambient. On occasion, some traders may resort to triggering ripening in the same way as with ethylene but using acetylene generated from small quantities of calcium carbide and water in an enclosed room. This practice tends to give fruit which are overly soft for their appearance and with a short market life. In addition, it is very dangerous to use acetylene because of its explosive properties.

Ripening of avocado and mango can also be achieved using controlled ethylene exposure but its use in the tropical exporting countries will depend upon the market to be supplied and individual importers/buyers requirements. In several countires these fruits are still ripened by using calcium carbide.

Curing of root crops and onions

One of the most important methods of reducing postharvest losses in many root crops such as potatoes, colocasia, yam and sweet potato and also for onions, is the use of surface drying and curing processes. Curing is accomplished by holding the produce at high temperature and high relative humidity for several days while harvesting wounds heal and a new, protective layer of cells form. While curing can be initially costly, the long extension of storage life makes the practice economically worthwhile. The best conditions for curing vary among crops as shown in the following table:

Commodity	**Temperature**		**Relative Humidity**	**Days**
	^{o}C	**^{o}F**	**(%)**	
Potato	15-20	59-68	90-95	5-10
Sweet potato	30-32	86-90	85-90	4-7
Yarns	32-40	90-104	90-100	1-4
Cassava	30-40	86-104	90-95	2-5

Curing is a natural wound healing process which in sweet potato replaces and strengthens damaged areas by forming a corky layer which protects against water loss and infection by decay organisms.

In contrast, the curing of onions is mainly a drying process where excess moisture is removed from the outer skin and neck of the onion. At the same time, by exposing the onion to higher temperatures, the colour of the skin darkens and natural fungicidal compounds accumulate in the skin. Both processes together ensure the formation of protecting layer, which greatly reduces water loss and serves as a physical and chemical barrier to infection.

i. Curing of root crops

Regardless of root crop to be cured, the following conditions should be established for all:

- the roots and tubers must be kept at the right temperature to stimulate skin growth, and this is normally above ambient temperature;
- the air around the roots or tubers must be moist but without free moisture on the surface dry air will cause injured surfaces to dry out quickly but free moisture will allow spoilage organisms entry into the tuber before the protective layer forms;
- skin growth needs oxygen so ventilation is needed but not too much or the produce will dry out and temperatures are also likely to drop.

All root and tuber crops suffer some damage during harvest and handling so curing should be

carried out as soon as possible after harvest. In many countries, sweet potato is still largely traded without a proper curing treatment. Often the uncured tubers are bundled straight into crocus bags with damp soil still attached to the surface and the poorly ventilated bags roughly handled and loaded into unventilated ships holds. It should not be surprising that postharvest losses are often very high.

The most simple curing practice for sweet potato involves firstly careful harvest (not when the soil is too wet) and simple stacking of the produce in field crates or in small heaps, off the ground in a shaded, sheltered and well ventilated spot under ambient conditions. The curing process should be completed in 3 to 5 days after which the tubers can be washed if necessary, graded, packed and distributed.

ii. ***Curing of onion***

Curing of onions is most conveniently performed in the field by the 'windrowing' method. Windrowing of onions is performed by carefully pulling or lifting the onions at harvest and simply laying them in their places to dry with the leaves of one row covering the bulbs of the next row in order to promote thorough drying of the tops while protecting the bulbs from undue sunburn. The bulbs should be turned regularly to ensure even drying and curing and should always be turned after a rain shower to make sure they are not touching wet soil continuously. If rainfall persists, then the onions must be dried and cured on special racks which can be easily and cheaply constructed from locally available materials. Polythene sheets should be fixed to the edge of the roof to let down quickly in the event of heavy rain showers and removed afterwards.

Curing is considered complete when the outer scales and neck are sufficiently dry to 'rustle' when handled and they form a tight cover over the bulb. Development of skin colour is also completed at this stage, some 10 to 12 days after harvest.

Unfortunately, most onions grown in different countries are seldom sufficiently cured, in the field or otherwise, before marketing. Hence, postharvest losses due to rots and sprouting are too high in onions.

Sprout inhibition

When crops such as onions, garlic and potatoes are placed in long-term storage, they tend to sprout, root and eventually rot. Sprouting can be avoided under such conditions by using varieties with long dormancy periods, proper curing and the use of chemical sprout suppressants such as 'Tecnazene' (TNCB), 'Chlorpropham' (CIPC), or other proprietary chemicals.

Fungicide application

Most postharvest losses eventually result from invasion and breakdown of the produce by microorganisms, although physical injury and stress caused by poor handling may predispose the produce to such attacks. In the spoilage of vegetables, bacteria can be the most important spoilage organisms, but since bactericides are not suitable for application to fresh produce, control must be largely by other methods. Chlorinated disinfectants are beneficial in cooling and washing water but are difficult to use effectively because the chlorine tends to combine readily with dirt and debris and ceases to be effective.

Fungi are usually the primary agents in the spoilage of fresh produce and control is possible by the application of fungicides at dose rates which do not harm the produce nor the consumer of the produce. If the produce is to be marketed and consumed rapidly after harvest, then fungicides may not be necessary or their use may be uneconomical if the value of the produce is low or the effect of the fungicide is not sufficiently significant.

Fruits in particular suffer from fungal infections. Often infections established in the field may remain dormant until after harvest and decay only develops during postharvest ripening. These

so-called 'latent' infections are of great importance to crops such as bananas, mangoes and avocadoes, where anthracnose infections are not seen by the exporter but may totally prevent their purchase in the export market if not controlled.

Fungicides are nearly always applied in the form of an aqueous solution or suspension and thus only to produce which is normally washed before packing.The most common application methods are:

i. **Spray or mist** - when application is by a hand-held knapsack sprayer for small-scale operations, or a mechanical spray set up on a moving belt or roller-conveyor for large-scale commercial operations. Both systems normally include provision for agitation of the spray mixture. Spraying should be done to the point of run-oof to ensure a complete cover of fungicide.

ii. **Drenching -** is a simple mechanical re-circulating system in which the fungicide is pumped in a cascade over produce passing beneath it on a belt or roller-conveyor. It has the advantage that there are no spray nozzles to wear away or become blocked. The combination of reservoir design and a high flow-rate pump keep the mixture agitated. A disadvantage of the system is that the high flow-rate and agitation may cause the fungicide to be dragged out of suspension and float on the foam generated by the agitation. It may be necessary to add a non-toxic anti-foam agent to prevent this happening.

iii. **Dipping** - is normally used where small quantities are to be treated. The fungicide mixture is made up in a small bath and produce dipped by hand. Excess fungicide is allowed to drain back into the bath. The fungicide mixture must of course be agitated frequently by hand. It is advisable to wear rubber gloves because some people develop allergic skin reactions to the fungicide mixture.

iv. **Smoke or fumigant** - is rarely used as an application method for fungicides. Tecnazene, which is a fungicide as well as a sprout suppressant, is applied in the form of volatile granules in long-term Irish potato stores, and 'diphenyl' wraps or pads may be used for citrus.

Hot water treatment

Although not used for treatment of vegetables and delicate fruits, hot water immersion of mango and papaya has been shown to help control latent 'Anthracuose' development. The hot water treatment is usually combined with fungicide application to promote the most effective control and save additional handling and equipment.

Generally, there are two main variants of the hot water treatment:

i. Dip in hot water at 55^{o}C for 5 minutes. Heat injury can develop when the mangoes are placed in cold storage after treatment - do not therefore dip in hot water when fruits are to be stored.

ii. Dip in hot water at 52^{o}C with Benomyl (Benlate) at 0.1% concentration, for 1 to 3 minutes.

Hot water treatment requires a lot more management and supervision to ensure that the water temperature and dipping time are strictly adhered to because there is little margin for error. Commercial scale equipment for treating larger volumes of fruit have yet to be acquired in the region and even in more developed countries the apparatus is still undergoing further development.

Fumigation and vapour heat Treatment (VHT)

Fumigation of fruits was traditionally for control of disease, as in the case of sulphur dioxide fumigation of grapes to control Botrytis and other fungus diseases, or for control of insect pests for quarantine purposes, principally against fruit flies.

Quarantine regulations in the USA and Japan require that certain produce from areas where fruit fly is endemic must be disinfested on or during importation, by approved and controlled methods. This was formerly achieved by fumigation with ethylene dibromide (EDB) or methyl bromide (MB). These chemicals have since been banned by many countries fo fear of toxic residues on the treated fruits. For the present, there are no suitable alternatives and areas with fruit fly have no opportunity to export fruits such as mango to the USA unless treated with hot water.

Vapour heat treatment may be used where other fumigants may damage the produce. The treatment consists of circulating saturated water vapour at high temperature around the produce in an enclosed store until the produce reaches the required temperature, usually in about eight hours, and the produce is then held at that temperature for a further six hours. Clearly most fruits such as avocado, lemon and most vegetables would injured by this treatment, but other kinds of citrus may be treated with vapour heat without serious Injury. However, it is highly successful to get rid of stone weevil in mango. The method is not in widespread use on account of its cost and impracticality but considered as a most viable alternative to EDB fumigation worldwide.

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