PACKHOUSE PRECAUTIONS

1 INTRODUCTION

Post-harvest decay control within integrated fruit production

Integrated Fruit Production within the southern African citrus industry incorporates the optimal integration of all production practices, from cultivar selection prior to planting to post-harvest decay control. Many forms of post-harvest decay result from pre-harvest infection. The incidence of post-harvest decay can therefore be influenced extensively by pre-harvest practices such as plant protection sprays, removal of dead wood, orchard hygiene, skirting of trees, mulching, and the control of fruit fly, false codling moth and mealybugs. Likewise, harvesting and fruit handling practices, as well as fruit maturity can influence the level of decay.

Other production practices such as fertilisation, irrigation, pruning, management of root health and pre-harvest chemical treatments influence fruit condition which in turn affects the incidence of decay. Furthermore, manipulation of microclimatic conditions within the orchard, by siting of the planting during establishment, can influence the incidence of post-harvest decay.

Management of numerous pre-harvest practices, in view of their impact on post-harvest decay, are therefore of importance in pursuing cost efficiency, sustainability and minimisation of environmental impact, being the goals of integrated fruit production.

2 PACKHOUSE PRECAUTIONS

2.1 Prevention of injuries

The entire packing line should be checked regularly for sharp objects such as protruding nails or screws, sharp edges, hard wax accumulations, defective or worn brushes (short, stiff hairs can injure the fruit), defective fruit sizing equipment, etc. Graders and packers should wear gloves.

Where fruit is packed unwrapped, packers should wear gloves on both hands since in most cases both hands are used to take fruit from the packing bin. Where alternate layers are wrapped, the packer must wear a glove on the hand used to pick up the fruit. If the other hand is without a glove (to pick up the wrapper) but comes into contact with the fruit during the wrapping process, it is important to check every morning that the fingernails of packers are short and cannot injure fruit.

Several methods are available for determining the amount of injuries to fruit, both on arrival at the packhouse and at any point in the packhouse line to determine whether the latter is causing any damage to the fruit. Unprocessed fruit must be used for this purpose.

Aluminium foil method - This method can be used to determine whether fruit is being injured during transport or during washing, drying and sizing. A number of fruit are wrapped in aluminium foil (thickness equals 0,009 mm or thinner). These fruit are then placed at random points in the trailer or put through the packhouse line and checked after passing over certain units, to determine whether any tears have resulted. Any operation that results in tear marks will also injure the rind of fruit.

Indigo carmine stain; TTC stain & Ferric chloride stain - As described under Pre-packhouse Precautions.

2.2 Prevention of oleocellosis

The following are potential areas in the packhouse where oleo can start or be aggravated:

High pressure water descaling unit. Reduce the water pressure for oleo-susceptible fruit (use 1500 kPa instead of 2000 kPa, as recommended). Brush speed on the white (wet) brushes should not exceed 120 rpm.

The hot bath. Reduce temperature to 39°C or lower. Hot water promotes the development of oleocellosis.

Do-nut and brass rollers. Maximum speed 60 rpm.

Black polisher brushes and wax unit brushes. Maximum speed 100 rpm.

Remove wax nodules and other potential points of damage in the packhouse line, e.g. on conveyor belts, guides, aluminium rollers in the drying tunnel, etc.

2.3 Dry packing lines

In some citrus producing areas the fruit need only to be brushed, and not washed, before it is ready for fungicide application in water or in wax. The fruit is cleaned on roller brushes and the dust removed by means of an extractor fan. Fungal spores may accumulate on the brushes, serving as a source of infection for injured fruit passing over the brushes. The brushing unit should therefore be disinfected every night. Fumigation with formaldehyde appears to be the most effective way of achieving this. For the application of fungicides in wax, see "Methods of application".

2.4 Dry-dumping of fruit

In packhouses using a dry-dump system, it is also essential to prevent spore accumulation in the first water bath or in the wet-roller section. See "Washing of fruit".

2.5 Chlorination of dump tanks

Spores of green mould, blue mould, the sour rot fungus, zoospores of *Phytophthora*, etc. accumulate in dump tanks by being washed off the surface of incoming fruit. It has been found that 50000 spores can be carried into the tank by one normal, sound fruit. Once a few hundred kilograms of fruit have passed through the tank, the spore concentration in the water of the dump tank becomes very high and unless the water is disinfected, it serves as an ideal source of infection for injured fruit. To avoid this, chlorination of dump tanks is essential. Copper sulphate is very effective against zoospores of *Phytophthora*, but less effective against spores of other pathogens.

The activity of chlorine against fungal spores depends on the concentration of active chlorine, time of exposure and pH (acidity or alkalinity) of the solution. Chlorine does not penetrate into wounds and a subsequent fungicidal treatment in the packhouse will therefore still be necessary to control post-harvest decay.

2.5.1 Methods of chlorination

One of the following methods may be used to chlorinate the water of the dump tank:

a) Calcium hypochlorite (granular chlorine, e.g. HTH)

This form of chlorine is readily available as a powder containing 70% available chlorine. The recommended concentration is 1,5 kg calcium hypochlorite (70% available chlorine) per 5000 litres of water. (200 ppm available chlorine, as determined by the Lovibond Comparator, or 50 ppm free active chlorine, as determined by the DPD test).

b) Calcium hypochlorite tablets

Details of this method of chlorination are available from:

Control Chemicals (Pty) Ltd
Klorman System
70 13th Street
JOHANNESBURG 2000
Tel: 011-7867166/9

c) Gas chlorination

This is a simple system, which is easy to use. No extra chemicals have to be added to the dump tank and the pH of the water is reduced during chlorination to ensure maximum free, active chlorine at all times. The gas is contained in steel cylinders, which are easy to handle and store. It is the ideal system for areas where the packhouse water has a high pH. The system is available from:

Dormas (Pty) Ltd
67 Second Street

Booysens Reserve
JOHANNESBURG 2091
Tel: 011-8353281/8

d) Chorine dioxide (Oxine, Harvest Wash)

This product is still under development. Once adaptation of the process for use in citrus packhouses has been finalised it may offer some very important benefits, e.g. the product is active over a wide pH range, it is not very corrosive, does not react readily with many types of organic matter (fewer concentration adjustments may be necessary) and is a very safe product.

The system is available from:

BTC Products and Services
PO Box 1611
RANDBURG 2125
Tel: 011-7932063

2.5.2 Wetting agents in the chlorinated water

For improved wetting of the fruit surface and of blue and green mould spores, a small amount of detergent may be added to the chlorinated water. It will improve the germicidal effect of the chlorine solution. The detergent should be used at a concentration of 0,02% (i.e. 200 ml per 1000 litres water). Anionic or nonionic wetting agents may be used, e.g. Tergitol XD, Teepol, Agral 90, G-49, Triton GR-5, etc.

2.5.3 Economical use of chlorine

The following procedures will ensure that a minimum of chlorine is used:

Fill the dump tank with reasonably clean water. Muddy river water will require much more chlorine than clean water to establish a level of 200 ppm available chlorine or 50 ppm free, active chlorine.

The fruit must be as dust free as possible, i.e. fruit transported for long distances over dusty roads, must be covered with canvas.

Mud should be removed from the dump tank regularly.

Protecting the dump tank from direct sunlight will reduce the amount of chlorine used.

2.6 Pre-grading for decayed fruit

Under no circumstances should partly decomposed fruit or fruit showing visible signs of mould spores be allowed into the packhouse. Enough graders should be used so that all infected fruit (stung fruit with visible infections of green and blue mould or sour rot, *Phytophthora*, brown rot, etc.) are removed before contamination of brushes in the washing line can occur. If a partly decomposed fruit is found on the grading tables or in the packing bins, the whole line should be thoroughly disinfected by using one of the disinfectants mentioned below.

Culled fruit, especially those already treated with fungicides, should not be allowed to remain in or near the packhouse to develop any mould spores and should be finely chopped and spread out to dry or be buried.

2.7 Washing of fruit

Washing of fruit with liquid soap mixed with fungicides has a beneficial effect. Where use is made of the dry dumping technique it is essential to disinfect the wet brush unit to prevent it from becoming a source of infection.

Fruit dumped in chlorinated water may only need a clean water rinse on a brushing unit or a pure soap solution or one of the undermentioned soap solutions may be used.

The following are examples of fungicide-containing soap solutions:

Deccosol, when diluted by adding 1 part Deccosol to 9 parts water, contains 2% sodium orthophenylphenate (SOPP). It can either be used in the form of a foam curtain (where this will not be disturbed by air movement) or as a spray.

Home-made SOPP soap. Mix 20 g SOPP (Dowicide A, Preventol ON Extra, Sofonate) plus 1 ml sodium dodecyl benzine sulphonate (or any

other anionic wetting agent) plus 2 g sodium carbonate (washing-soda, Na_2CO_3) per litre water.
Soap containing quaternary ammonium compounds such as Sporekill.

Thoroughly brush the soaped fruit on roller brushes (approximately 12 brushes, 110 to 120 rpm) and rinse thoroughly with clean water delivered by fan type spray nozzles (70 kPa to 250 kPa) or a high pressure spray machine (do no exceed 2000 kPa for soft citrus, lemons [green] and soft midseason cultivars, up to a maximum of 4000 kPa for "tough" skin cultivars).

2.8 Descaler

The descaler is a device for removing dead or live red scale (*Aonidiella aurantii*) from the surface of citrus fruit in the packhouse. It consists of 6 to 12 parallel booms, each fitted with 10 to 15 nozzles approximately 75 to 100 mm apart and staggered with respect to the adjacent boom. D2 and D3 discs and number 56 whirlers are used.

The booms are fitted between roller brushes, the nozzles are approximately 175 to 250 mm above the level of the brushes (distance must be adjustable to accommodate different sizes of fruit) and each nozzle delivers approximately 2,5 to 5,5 litres water per minute at a pressure of 2000 to 4000 kPa. The fruit spends approximately 10 seconds under the nozzles.

It is essential that the water used is filtered to remove any solid particles which may clog the nozzles and damage the fruit. Fruit moving too slowly may be damaged, especially poorly coloured fruit early in the season or fruit showing serious creasing. Other fruit that may be damaged by the descaler include sensitive skinned midseason varieties, mandarin types and sometimes lemons. The injuries will be aggravated if the fruit is treated with SOPP after passing through the descaler.

The descaler should be installed immediately following the bulk dumping tank or dry dumping area and preferably outside the packhouse to prevent a build-up of humidity in the packhouse atmosphere. High humidity leads to difficulties in drying the fruit after waxing.

Fruit which is dumped into chlorinated water should not be rinsed before entering the descaler since the chlorine residues will help to disinfect the brushes. Where dry dumping is used or where the water used in the descaler is recirculated, such water should be chlorinated. It is probably best to use a liquid bleach (sodium hypochlorite) for this purpose since calcium hypochlorite (e.g. HTH) tends to form a precipitate which may clog nozzles. Calcium hypochlorite may be used if the precipitate is allowed to settle out and a clear supernatant is used. Other methods of chlorination may be used, such as gaseous chlorine or the KLORMAN system. If a descaler is used, there is no further need to wash the fruit with soap and water.

Where live scale is removed from citrus fruit, a droplet of juice may form due to capillary action via the mouth parts of the scale which remain embedded in the rind of the fruit. *Cladosporium* sooty mould often develops on the juice, making the fruit unsightly and leading to rejections at the port. It has been found that a hot water treatment (3 minutes at 47°C) helps to prevent such growth. Further control is obtained by using SOPP (Dowicide A) or imazalil in the hot water or imazalil in wax.

2.9 Pre-grading to remove factory fruit

Juice standards on overseas markets have become very strict with regard to fungicide residues. The tolerance allowed for fungicide residues in juice is approximately 0 to 10 parts per billion. It is therefore vital that packhouses remove all factory fruit prior to any fungicide being applied in the packhouse.

Chlorine treatment of fruit does not pose a problem.

2.10 Use of ultra violet light (UV light) during grading

Fungal infection of fruit in orchards can assume serious proportions during certain seasons,

depending on climatic conditions and insect activity. Numerous stung or infected fruit, which are very difficult to identify with the naked eye, are then brought into the packhouse and escape detection by the graders. In these instances UV light can be of invaluable assistance in identifying and grading out such fruit.

When oranges which are infected with blue or green mould and showing a soft, water-soaked lesion of 1 cm diameter or less, are placed under or near the UV light, the affected areas will fluoresce yellow against a dark purple background. Infected Valencia orange tissue fluoresces bright yellow, tissue of Washington navel fluoresces a dull yellow, while lemon tissue apparently does not fluoresce.

From Israel it is reported that punctures and fissures fluoresce dull green-yellow, but that *Diplodia*-infected tissue ceases to fluoresce as soon as the brown colour develops. One or more UV light booths constructed of wood or curtains can be installed over a roller conveyor immediately following the bulk dumping tank or dumping area or further along the line. Inside the booth the walls and equipment should be painted black to avoid reflection into the eyes of graders and to achieve low light intensity. The UV lights must be suspended over the roller conveyor at such a height that the faces of the graders are shielded from direct radiation, since direct exposure of the eyes will cause fluorescence inside the eyeball, leading to bad grading. Metal or enamel reflectors should be used to reflect the UV light downward onto the fruit. Two 40 watt tubular lamps, 1,23 m (4 ft) long, emitting long UV light waves (approximately 360 nanometres or millimicrons) mounted over a roller conveyor should be sufficient.

2.11 Hot water bath

The only way to eliminate established *Phytophthora* infections (causing brown rot), is by immersing infected fruit in hot water. The temperature of the water, period of immersion and the period between infection and treatment are critical. In practice, however, the eradication of established *Phytophthora* infections by means of a hot water treatment is of limited value. **The most practical way of avoiding losses, is by preventing infection in the orchard before picking.** (See earlier section).

A hot water bath may be used to enhance the activity of fungicides such as SOPP and 2,4-D. A hot water treatment (3 minutes at 47°C) helps in preventing the development of *Cladosporium* sooty mould on fruit from live red scale that has been removed by means of high pressure water sprays.

Fruit attacked by FCM or fruit fly can be detected in a hot water bath at temperatures above 49°C by the release of air bubbles from insect stings.

Dipping fruit in hot water (above 32°C) facilitates drying before fungicide or wax application, thus enhancing the efficacy of these processes.

However, dipping in hot water may cause fissures in fruit seriously affected by creasing. Temperature of water used for treating such fruit should be lowered to approximately 32°C.

2.12 Drying of fruit prior to fungicide application

Fruit which has been washed or dipped in a hot water bath must be properly dried - moist dry before entering a fungicide dip tank and absolutely dry if the fungicide is sprayed on or brushed on in water or in wax.

The drying units preceding and following fungicide application should be equipped with a minimum number of brushes (maximum 20 brushes). After fungicide application in water, the fruit should ideally be dried with hot air on aluminium rollers.

2.13 Selecting fungicides for post-harvest decay control

The application of post-harvest fungicides to all fruit offered for export is compulsory to maintain customer confidence that citrus fruit sold has excellent keeping qualities.

Selection of fungicides for post harvest protection of citrus is a complex matter and is determined by the climate of a particular production area, the variety, the particular pathogens to be controlled, length of storage, etc. Most fungicides in use today have a limited spectrum of action; in other words, they are toxic to certain species of fungi but not to others. Fungi may also develop resistance towards a particular fungicide or group of fungicides. Therefore combining two or more fungicides should provide broader, more comprehensive protection.

- Imazalil (Fungazil, Sanazil, Magnate)

  Imazalil is excellent for use against the Penicillium fungi (blue and green mould) and is reasonably active against *Diplodia* stem end rot, *Phomopsis* stem end rot, *Trichoderma* brown rot and anthracnose brown rot (*Colletotrichum*).

- Guazatine (Deccotine, Deccowax)

  Guazatine is the most effective fungicide registered for the control of sour rot (*Geotrichum*) and provides excellent control of green mould. It is also active against blue mould, *Diplodia* and *Phomopsis* stem end rot and *Alternaria* rot.

- Thiabendazole (TBZ, Tecto Flowable, Tecto 100)

  Thiabendazole (TBZ) is the most effective fungicide registered for the control of *Diplodia* and *Phomopsis* stem end rot and is also very effective against sensitive strains of *Penicillium* (blue and green mould). In many production areas *Penicillium* strains have developed resistance to TBZ. TBZ is also effective against anthracnose rot, *Fusarium* brown rot and *Trichoderma* brown rot.

- Sodium orthophenylphenate (SOPP, Dowicide A, SOPP solution, Preventol ON Extra, Sofonate)

  SOPP is reasonably active against the *Penicillium* fungi (blue and green mould) and provides a high degree of protection against *Geotrichum* sour rout and *Alternaria* rot.

- Sodium - 2,4-D (Deccomone)

  The sodium salt of 2,4-D is the only formulation of 2,4-D registered for post harvest use in South Africa. This hormone is used to prevent abscission of the stem end button of the fruit which, if it becomes loose or falls off, enables the *Diplodia* and *Alternaria* fungi to penetrate the fruit, causing stem end or core rot. Fruit also has a fresher appearance if the button is green and intact.

3 METHODS OF APPLICATION

3.1 Fungicide application in water or in wax

Best decay control is obtained if harvested fruit is treated promptly with fungicides. During hot weather (average temperature 20°C or higher), the fruit must be treated within 24 hours after picking. In cooler weather (15°C or lower) treatment may be postponed for 48 to 72 hours after picking. Application of post-harvest fungicides in water is by far the most effective, whether it is a dip, drench, spray-on or brush-on treatment. When applied in wax, fungicide concentrations must be increased two- or three-fold to approach the same level of decay control achieved when applied in water only.

3.1.1 Fungicide application in water baths

This is the most effective method of applying water soluble fungicides and can be combined with the hot water bath.

Topping up rates for fungicides must be chemically determined. See “Dip treatment in a water bath”.

The fruit must be immersed for at least 15 to 30 seconds, but preferably for longer to enable to fungicide mixture to penetrate all injuries.

Unlike non-recovery spray-on or brush-on systems, fungicide concentrations used in dip

tanks, may be reduced. Some fungicides such as guazatine (good control of sour rot) and SOPP are more effective when applied in dip tanks. This method is subject to certain conditions in cases where fungicide concentrations cannot be chemically determined.

Fruit must be clean and dry on entering the dump tank to avoid dilution of the fungicide mixture.

The dump tank must be small enough to be topped up with fungicide mixture on a regular basis during the day. This will prevent fungicide concentrations falling below certain levels and makes it possible to dispense with the regular determination of the concentration of fungicide used in the treatment.

Growers with consistently high levels of decay are advised to modify their packhouse lines in order to incorporate a dip tank treatment.

3.1.2 Drench method

This method probably is as effective as a dip treatment if applied as a continuous spray of fungicide mixture across a set of moving rollers for at least 30 seconds. Normally the fungicide mixture is recirculated and most of the above comments concerning dip tanks also apply to this method.

3.1.3 Non-recovery spray- or brush-on method

The fungicide solution or suspension is sprayed or brushed on while the fruit is turning on the brushes. Unless the fungicide is soluble in water, the suspension in the fungicide tank must be agitated continuously during use. The fruit must be in contact with the fungicide soaked brushes for at least 30 seconds.

In non-recovery systems, i.e. systems where the fungicide is sprayed on, at least 1,5 ml fungicide per kg fruit must be used.

Provided the spray-on or brush-on systems are applied correctly, satisfactory decay control is obtained. However, a recent survey showed that in more than 80% of the packhouses used in the sample, the systems did not work probably due to: clogged spray nozzles, under-application of fungicide mixture, exposure period to the fungicide mixture not long enough (i.e. less than 30 seconds), empty fungicide tanks, feed rate of fruit too fast, etc.

The fruit must be damp-dry when entering the applicator and it is vital that the entire fruit surface be covered. Decay control will be less effective if the fungicide concentration is increased but less fungicide mixture than recommended is used. Where the fruit is not washed, but only dry-brushed, more fungicide mixture than recommended above, as well as a suitable surfactant may be necessary to ensure proper wetting and coverage of the fruit. The brushes in the fungicide applicator must be completely wet and saturated with fungicide mixture before the fruit passes over them. Avoid clogging of pumps and/or nozzles and pumps not delivering enough fungicide mixture through the nozzles. The fungicide tank should not be allowed to run dry before topping up takes place, since the applicator brushes will become too dry and poor application will result. Fans used for drying fruit should be tilted away from the applicator brushes to prevent drying these.

One method of determining whether the fungicide mixture is applied effectively, is to check the recommended application rate of 1,5 ml fungicide mixture per kg fruit. The application rate can be determined as follows:

(i) Choose a slat elevator as close to the fungicide applicator as possible and determine how many fruit/carrying slats move past a fixed point in one minute (fruit carrying slats per minute).

(ii) Stop the elevator and remove and weigh the fruit from as many slats as possible to determine the weight of fruit per slat in kilograms.

(iii) The feed rate in kilogram per minute can be determined from (i) and (ii), e.g. 10 kg fruit on 5 slats equals 2 kilogram per slat; say 60 slats per minute from (i)

gives 2 x 60 = 120 kg fruit per minute.

(iv) Now measure the amount of fungicide mixture delivered onto the brushes during 1 minute, say 180 ml. This can be done by holding a beaker under the delivery outlet for 1 minute and pouring the solution thus collected into a measuring cylinder (calibrated in ml).

(v) Application rate is 180 ml per 120 kg of fruit per minute, i.e. 1,5 ml fungicide mixture per kg fruit.

3.1.4 Application of fungicide mixtures in waxes

Although reasonably good control of decay is possible by mixing fungicides with waxes and applying the mixture as a non-recovery treatment, this method is the least effective since penetration of the injuries by the fungicide is poor. However, residues are higher, which does help to control sporulation.

If the fungicide is not fully soluble in wax (e.g. Tecto), continuous agitation of the mixture is necessary. Apply at least 1,5 ml wax mixture per kg of fruit. To determine this, see "Non-recovery spray-on or brush-on".

3.2 Fungicide application rates

3.2.1 Imazalil sulphate (Fungazil 750-SP, Sanazil 750-SP or Magnate 750-SP)

This is currently the most effective fungicide for the control of blue and green mould. Strains of blue and green mould that are resistant to TBZ are found to a greater or lesser extent in all production areas. The result is unreliable control of these diseases by TBZ. Imazalil also controls *Diplodia* stem end rot, *Alternaria* rot, anthracnose rot and *Trichoderma* brown rot, but is not effective against sour rot or *Phytophthora* brown rot.

a) <u>Dip treatment in a water bath</u>

- *Imazalil concentration*

This is the most reliable method of ensuring that every fruit is fully covered with fungicide mixture. Immerse for 15-180 seconds in 667 g imazalil sulphate (Fungazil 750-SP, Magnate 750-SP or Sanazil 750-SP) per 1000 litres of water (500 ppm a.i.).

- *Temperature of this fungicide solution*

Early season fruit, green coloured fruit and soft citrus cultivars, irrespective of colour, should not be dipped in water of 40°C and higher. Water of up to 47°C may be used for ripe, well coloured fruit. Heating the fungicide solution will facilitate drying of fruit prior to waxing. Imazalil sulphate may be combined with guazatine (Deccotine) and 2,4-D sodium salt (Deccomone) in the water bath.

- *pH of the imazalil solution*

The pH of the imazalil bath should be maintained at between at between 4 and 7. Use acetic acid to reduce the pH and sodium bicarbonate to increase the pH, where necessary.

- *Compatibility*

Imazalil sulphate is incompatible with SOPP, calcium hypochlorite and alkaline water emulsion waxes such as Citrashine, Tag, Citraglo, Stafresh, etc.

- *Maintaining concentration*

Topping up rates will vary from packhouse to packhouse. Where imazalil sulphate only is used or where it is combined with 2,4-D sodium salt, the titration method described below may be used to determine the topping up rate. If guazatine (Deccotine) is also present, the titration method will not be accurate. In these cases guazatine should be applied in wax (Deccowax) for a day or two while the topping up rates for imazalil sulphate solutions in the baths are determined.

Determining imazalil concentrations

(Fungazil 750-SP) in the water baths of citrus packhouses by means of a two-phase titration method.

- *Apparatus required*

25 ml Burette (graduated in 0,02 ml)
2 x 1000 ml volumetric flasks
1 x 1000 ml Erlenmeyer flask with glass stopper
2 x 750 ml Erlenmeyer flasks with glass stoppers
1 x 25 ml } measuring cylinders
1 x 100 ml }
1 x 250 ml }
1 x indicator drop per bottle
1 x plastic wash bottle
1 x funnel
1 x 250 ml beaker
1 x Burette stand with clamps

- *Solutions required*

1. 1 M sulphuric acid (54,5 ml 98% pure sulphuric acid per litre distilled water).

2. Dichloromethane AR (undiluted).

3. Indophenol blue indicator (50 mg indophenol blue per 100 ml dichloromethane).

4. Titration solution. Dissolve in distilled water 2,8 g sodium lauryl sulphate (99% pure) and make up to one litre.

   Allow a freshly prepared solution to stand for 2 days before use. Pour into a plastic wash bottle, which is easier to use when filling the burette.

- *Procedure*

i) Pour 25 ml imazalil solution into a 750 ml Erlenmeyer flask.

ii) Add 10 ml of solution 1 (sulphuric acid).

iii) Add 25 ml of solution 2 (dichloromethane).

iv) Add ± 12 drops of solution 3 (indophenol blue). Mix the contents of the 750 ml Erlenmeyer flask well.

v) Clamp the burette in the stand and fill to the 0 ml mark with solution 4 (sodium lauryl sulphate) from the wash bottle.

vi) Titrate the solution in the 750 ml Erlenmeyer flask with solution 4 in the burette and stir continuously until the colour of the indicator changes from blue to light yellow (the colour change is in the organic solvent phase). This is the end-point of the titration. Read the quantity of solution 4 in the burette used to reach the end-point = A ml.

vii) Repeat the above titration, using the following:

250 ml water (distilled) in the 750 ml Erlenmeyer flask
Add 10 ml of solution 1
Add 25 ml of solution 2
Add ± 12 drops of solution 3.
Titrate the solution in the Erlenmeyer flask with solution 4 in the burette, as above, until the end-point is reached. Take a reading from the burette as above = B ml. This is called a blank or standard reading.

Calculation: (A ml - B) x 0,01 x 40 x 297,18 = ppm imazalil (mg/l).

The following formula can be used to calculate the amount of imazalil sulphate which should be added to the water bath to restore the imazalil concentration to 500 ppm a.i.:

$$\frac{b \times (500 - c)}{750} = \text{g imazalil sulphate}$$

b = volume of water bath in litres.
c = concentration in ppm, as determined by titration.

b) The drench method

Everything applicable to the dip method also applies to drenching. See "Dip treatment in a water bath".

The fungicide mixture is pumped from a reservoir installed underneath a series of roller brushes to a container with holes mounted above the roller brushes. The mixture is recirculated. This drench or flood method is used to pour fungicide mixture over the fruit for at least 30 seconds.

It is possible to combine the application of water insoluble fungicides (e.g. Tecto or Fungazil 800 EC) with that of water soluble fungicides (e.g. Fungazil 750-SP) provided the reservoir is designed for this purpose.

c) Spray-on or brush-on method

- *Concentration of imazalil sulphate*

Use 33 g of powder per 25 litres of water (approximately 1000 ppm). Dissolve the powder in a small amount of lukewarm water before adding it to the remainder of the water in the tank.

- *pH of the solution*

If the contents of the tank are used up within 12 hours of mixing, adjustment of the pH is unnecessary.

- *Compatibility*

Imazalil sulphate is compatible with Tecto (Flowable or 100), Deccotine and 2,4-D sodium salt, but not with SOPP, calcium hypochlorite, Ethrel or citrus waxes.

- *Application in wax*

Imazalil sulphate (Fungazil 750-SP, Sanazil 750-SP or Magnate 750-SP) cannot be applied in wax.

3.2.2 Imazalil base (Fungazil 800 EC, Sanazil 800 EC, Magnate 800 EC)

a) Spray-on or brush-on in water (non-recovery method)

- *Concentration*

Use 33 ml product per 25 litres water (approximately 1000 ppm a.i.). Mix thoroughly with a small amount of lukewarm water before adding to the main tank. Undiluted drops of the imazalil base may cause fruit burn.

- *pH of the imazalil emulsion*

If the tank is emptied (the contents used up) within 12 hours, adjustment of the pH is not necessary.

- *Compatibility*

Imazalil base is compatible with Tecto (Flowable or 100), Deccotine, 2,4-D sodium salt and Ethrel, but not with SOPP or calcium hypochlorite.

b) Drenching or flooding method

Because this method of application involves much agitation of the fungicide mixture (See "The drench method") imazalil base, which is insoluble in water, can be used in this system without precipitation of the active ingredient.

- *Concentration*

Use 625 ml product per 1000 litres water.

- *Topping-up*

Use the titration method to determine the imazalil concentration (see "Dip treatment in a water bath") or add 5 ml product for every 1000 kg fruit treated.

- *Compatibility and pH*

Imazalil base is compatible in this system with Deccotine, Tecto Flowable and 2,4-D. The pH must be maintained at between 6,5 and 7,5.

- *Application in wax*

Fungicides are generally less effective when applied in wax than when applied in water. However, when disease pressure is not high this method can result in satisfactory control.

Only imazalil base (e.g. Fungazil or Magnate 800 EC) can be applied in wax (not imazalil sulphate, e.g. Fungazil or Magnate 750-SP). Use 99 ml Fungazil 800 EC per 25 litres wax (approximately 3000 ppm active ingredient). First mix the EC formulation thoroughly in approximately 500 ml lukewarm water before adding it to the wax. Undiluted drops of the 800 EC formulation will cause fruit burn. Thoroughly stir the wax and imazalil for 15 minutes before use. Cover the entire surface (including stem and navel end) thoroughly with wax. Tecto 100, 2,4-D sodium salt and guazatine (in the form of Deccowax) may be combined with Fungazil 800 EC in a wax.

c) Dip treatment in a water bath

The use of imazalil base (Fungazil 800 EC, Sanazil 800 EC or Magnate 800 EC) in a water bath is not generally recommended due to the limited agitation of the fungicide mixtures in such a system. Precipitation may occur of products which are insoluble in water.

3.2.3 Guazatine (Deccotine, Deccowax)

Geotrichum sour rot and *Rhizopus* rot are post-harvest diseases that are becoming increasingly important and can only be satisfactorily controlled by using guazatine in the packhouse.

a) Dip treatment in a water bath Water soluble guazatine (Deccotine) or drench method (Deccotine)

- *Concentration*

Use 5 litres Deccotine per 1000 litres water (1000 ppm active ingredient) or 10 litres Deccotine per 1000 litres water (2000 parts per million), depending on the extent of the sour rot problem.

- *Temperature of solution*

Guazatine (Deccotine) is stable at all temperatures which are normally used in the packhouse.

- *pH of solution*

Ensure that the pH of the water is 7,5 or less before the Deccotine is added. Use addition of acetic acid to lower the pH and sodium carbonate to increase the pH.

- *Compatibility*

Deccotine is compatible with imazalil sulphate (Fungazil, Magnate or Sanazil 750 SP), imazalil base (Fungazil or Magnate 800 EC), TBZ (Tecto Flowable or 100), 2,4-D sodium salt and Ethrel. Deccotine is not compatible with SOPP, calcium hypochlorite or any active chlorine compounds and cannot be combined with citrus wax in the packhouse.

- *Adjustment of concentration in the water bath*

Top up at a rate of 20 ml Deccotine per 1000 kg fruit treated.

Guazatine is inclined to form a loose compound with organic matter present in the fungicide bath. This does not

result in guazatine becoming inactive, but the fungicide may settle out with the organic matter unless provision is made for adequate agitation.

It is recommended that guazatine dip tanks be equipped with some form of agitation (compressed air or circulation through pumps) where this tendency is observed.

b) Spray-on or brush-on of guazatine (non-recovery method) (Deccotine)

- *Concentration*

  Use 500 ml Deccotine per 25 litres water (4000 ppm).

- *pH of solution*

  Ensure that the pH of the water is 7,5 or less before the Deccotine is added. Use the addition of acetic acid to reduce the pH or sodium bicarbonate to increase the pH to approximately 7.

- *Compatibility*

  Deccotine is compatible with imazalil sulphate (Fungazil, Magnate or Sanazil 750 SP), imazalil base (Fungazil, or Magnate 800 EC), 2,4-D sodium salt, TBZ (Tecto Flowable or 100) and Ethrel. Deccotine is not compatible with SOPP, calcium hypochlorite or any other active chlorine compound and cannot be combined with citrus wax in the packhouse.

- *Application in wax (Deccowax)*

  Guazatine cannot be incorporated in water emulsion waxes by simply adding Deccotine to these waxes, as the guazatine becomes inactive. Guazatine can be incorporated into the wax during the wax manufacturing process. Deccowax containing 3000 ppm active guazatine is commercially available for use on citrus fruit for the control of sour rot. Fungazil 800 EC, Tecto 100 and 2,4-D sodium salt (Deccomone) can be used with Deccowax.

3.2.4 Thiabendazole (TBZ, Tecto Flowable, Tecto 100)

In production areas where resistance to TBZ is no problem, TBZ may be used for the control of blue and green mould, *Diplodia* stem end rot, anthracnose rot and *Trichoderma* brown rot. TBZ has no effect on *Alternaria* rot, sour rot or *Phytophthora* brown rot.

TBZ is insoluble and suspends poorly in water and is therefore not suitable for use in water baths. It is incompatible with SOPP in water, but may be used with SOPP in water emulsion waxes.

a) Spray-on or brush-on in water (non-recovery method), using Tecto Flowable

This is the best way of applying TBZ. Use 111 ml Tecto Flowable 45,1% in 25 litres water. This yields a treatment concentration of 2000 ppm TBZ. The suspension must be agitated continuously during use. The 25 litre mixture should be used to treat a maximum of 17 000 kg citrus fruit.

b) Application in water emulsion waxes (Citrashine, Deccowax, Citraglo and Stafresh)

Use 100 g Tecto 100 per 25 litres of wax for a treatment concentration of 4000 ppm TBZ. The suspension must be agitated continuously during use and may either be sprayed on or brushed on (total loss system). The 25 litres of wax and fungicide mixture should be used for the treatment of a maximum of 17000 kg fruit.

If Tecto Flowable is added to the wax, use 222 ml Tecto Flowable per 25 litres of wax. According to some reports, Tecto Flowable in wax may have an adverse effect on

shine.

c) Drench, flooding or water bath method (Tecto Flowable, recirculation system)

Since Tecto Flowable (and especially Tecto 100) suspend poorly in water (TBZ is insoluble in water), provision should be made for proper agitation (stirring action) should these products be used in such a system, to prevent precipitation of the active TBZ in the reservoir or water bath. Use 2200 ml Tecto Flowable per 1000 litres water (approximately 1000 mg a.i. per litre).

- *Topping-up*

Add 9 ml Tecto Flowable for every 1000 kg fruit treated.

3.2.5 2,4-D sodium salt (Deccomone) 25 g a.i./litre

South African citrus fruit is often stored for extended periods of time due to marketing circumstances. During this period the button of the fruit is inclined to fall off, thus exposing the fruit to *Alternaria citri* infection, the cause of core rot in citrus fruit. Application of 2,4-D is the only way to avoid such infection by preventing the button from falling off. The use of 2,4-D also assists in controlling *Diplodia* stem end rot.

a) Dip or drench treatment in water (recirculation system)

Use 10 litres Deccomone per 1000 litres water (250 mg a.i. per litre). Replace water removed from the bath with the above solution, adding additional 2,4-D at a rate of 20 ml Deccomone per 1000 kg fruit treated. 2,4-D is compatible with imazalil sulphate and Deccotine.

b) Application as a non-recovery brush-on or spray-on treatment in water

Use 250 ml product per 25 litres water (250 ppm). Apply at least 1,5 litres of mixture per 1000 kg fruit. Make sure that the buttons of the fruit are properly covered.

2,4-D sodium salt is compatible with imazalil sulphate, imazalil base (liquid imazalil), guazatine (Deccotine) and TBZ (Tecto Flowable)

c) Application in wax

Use 250 ml per 25 litres wax. 2,4-D sodium salt is compatible with imazalil base (800 EC), TBZ (Tecto 100) and Deccowax.

3.2.6 Sodium orthophenylphenate (SOPP, Dowicide A, Preventol ON Extra)

This water soluble fungicide provides fairly good protection against blue and green mould and is also active against *Diplodia* stem end rot, *Alternaria* rot and sour rot. SOPP is incompatible with TBZ in water. However, SOPP can be used with TBZ in water emulsion waxes. SOPP is not compatible with imazalil sulphate or with concentrations of imazalil 800 EC in excess of 100 ppm imazalil.

- **Precautions when using SOPP**

Incorrect use of SOPP may lead to **serious burns** on the rinds of citrus fruit.

Fruit picked early in the morning or turgid fruit should be wilted for 12 to 24 hours before immersion in SOPP solutions. Immersion time should not exceed 3 minutes and should be controlled by the use of a submerger or paddles.

The concentration of SOPP at the different temperatures should be accurately controlled by determining the capacity of the bath, accurately weighing out the necessary amount of fungicide and periodically determining the SOPP concentration by chemical means.

Control of the pH is very important; if the pH is too low, serious burns on fruit may result. Use a pH meter or accurate pH indicator paper to determine the pH.

The temperature should be controlled by means of a good thermostat. It is essential to determine the accuracy of the thermostat on a regular basis by using a thermometer. Too high a temperature, coupled with too high a SOPP concentration, will result in serious fruit burn.

Fruit should be rinsed after treatment with SOPP (with the exception of the 0,15% SOPP treatment if this is followed by the application of an alkaline water-based wax).

Lemons picked and packed on the same day should not be dipped in an SOPP bath, as this will cause injury in the form of red spots or stains. However, SOPP treatment of lemons is mostly safe if the fruit is allowed to wilt for 12 to 24 hours after picking.

Packhouses which experience high waste percentages in their fruit and would like to avail themselves of the extra protection offered by SOPP, should apply one of the following treatments. (Do not use SOPP and imazalil in the same dip treatment).

* *0,15% SOPP at 47°C maximum*

Use 0,75 kg Dowicide A per 500 litres water or 1,95 litres SOPP solution (35%) per 500 litres. Maintain the pH at between 10,7 and 11,0 by adding sodium hydroxide (caustic soda). The fruit should be immersed for 3 minutes. Rinsing is not necessary if the treatment is followed by waxing with an alkaline water-based wax. Rinse thoroughly if followed by dipping in imazalil sulphate.

* *0,5% SOPP at 32°C to 40.5°C*

Use 2,5 kg Dowicide A plus 1,25 kg hexamine per 500 litres water or 5,6 litres SOPP solution (35%) plus 1,25 kg hexamine per 500 litres water. The pH must be maintained at between 11,7 and 12,0 by the addition of sodium hydroxide (caustic soda). If the pH is maintained accurately, the use of hexamine is unnecessary. Dip the fruit for 3 minutes and rinse well with clean water.

* *1,5% SOPP at lower than 32°C*

Use 7,5 kg Dowicide A plus 3,75 kg hexamine and 0,75 kg caustic soda per 500 litres water or 19,48 litres SOPP solution (35%) plus the 3,75 kg hexamine and 0,75 kg caustic soda per 500 litres water. The pH must be maintained at between 11,7 and 12,0. Keep the fruit immersed for 3 minutes and then rinse with clean water. Provided the pH is carefully controlled, the use hexamine is not necessary.

Consult Mr. Keith Lesar if you are interested in methods for the determination of SOPP concentrations.

* *Topping-up of SOPP bath*

The amount of SOPP to be added daily will depend on the amount of water carried in with the fruit, the amount of SOPP solution carried out by the fruit and the amount of organic matter (e.g. dirt) carried into the bath by the fruit. Topping-up rates must be determined for each particular washing line.

The topping-up rate for a packhouse where the 0,15% SOPP solution was used, the bath was heated by steam pipes to 47°C and where clean fruit was put through the bath, was as follows: 1000 litres of the bath solution is used to treat 8000 kg fruit. Add 1/8 of the original amount of SOPP and adjust the pH to 10,7. This is approximately 25 g SOPP/1000 kg fruit per 1000 litre tank.

4 WAXING

All export citrus must be waxed. Good waxing of fruit is extremely important, especially when fungicides are mixed in the wax and when the fruit is packed unwrapped. When the fruit is examined for coverage, the button end in particular must be checked.

4.1 Types of waxes

Only water emulsion may be used on citrus fruit. Examples of water emulsion waxes are:

Citrashine Polygreen - for use on green and well coloured fruit.
Citrashine Polyorange - for use on well coloured fruit only.

Tag - for use on green and well coloured fruit.

Citraglo - for use on green and well coloured fruit

Stafresh – for use on well coloured fruit only.

(Also acceptable for Japan).

Deccowax Polygreen - for use on green and well coloured fruit.

Deccowax Polyorange - for use on well coloured fruit only.

Citrashine natural wax for use on citrus fruit destined for Japan.

The following precautions must be taken to ensure good coverage and shine:

- Apply enough wax - aim at using 1,5 ml wax per kilogram of fruit.
- Follow up with sufficient brush action. A minimum of 6 brushes is required and these should always be wet with wax.
- A good indication that the correct amount of wax is used, is when the last brush in the line and the dropboard are wet with wax, but without any sign of foaming.
- Drying facilities must be adequate. The fruit should be dry when entering the wax applicator, otherwise dilution of the wax occurs and the wax film may be impaired.
- Rinsing of fruit must be thorough to remove dirt or other chemicals such as SOPP. TBZ and 2,4-D applied in water prior to waxing will not affect shine provided the fruit is dry when the wax is applied.
- Do not overload the unit. Optimum feed rates are:

Fruit flow width	Kg fruit per minute
150 cm (5 ft)	400
120 cm (4 ft)	300
90 cm (3 ft)	200
60 cm (2 ft)	100

- Ensure a uniform flow of fruit through the applicator. Fluctuations in the feeding rate while the flow of wax remains constant will result in some fruit being over waxed and some under waxed. Foaming of water emulsion waxes will occur as a result.
- For economical reasons as many undergrade fruit, factory fruit and unwanted sizes should be removed before the fruit enters the wax applicator.

5 PACKHOUSE SANITATION

Under no circumstances should partly decomposed fruit or fruit showing visible signs of mould spores be allowed into the packhouse. Enough graders should be used so that all infected fruit (stung fruit with visible infections of blue and green mould or sour rot, *Phytophthora* brown rot, etc.) are removed before contamination of the brushes in the washing line can take place. If a partly decomposed fruit is found on a grading table or in a packing bin, the entire line should be thoroughly disinfected by using one of the disinfectants mentioned below.

Culled fruit, especially fruit already treated with fungicides, should not be allowed to remain in or near the packhouse to develop any mould spores, but should be chopped fine and spread out to dry or be buried.

Similarly, fungicide treated fruit destined for the local market (and which may have to remain in the packhouse for a few days awaiting railing instructions), may develop mould spores and should therefore preferably be kept in another building away from the packhouse. Spores on fruit already treated with a fungicide are most likely resistant to that specific fungicide.

The entire packhouse should be cleaned every day, and all fallen fruit collected and destroyed. The packhouse, and especially the packing line, should be disinfected every night. One or more of the following disinfectants may be used:

5.1 Quaternary ammonium compounds

Use a concentration of 2000 ppm active

ingredient. The solution can be used to wipe or wash or to spray onto equipment. Products currently available on the market include Sterimist (Cremark Chemicals), Sterilan QAC (Henkel), Odosan (F&D Distributors, Nelspruit), Multibac (Triple P Chemicals, Edenvale), Microban (Hi-Tech Chemical Controls, Nelspruit), BAC 50 (Thor Chemicals, Alberton), Sporekill (Hygrotech).

5.2 Formaldehyde

Available as an aqueous solution, *viz* formalin (40% formaldehyde). Formalin (50 ml/litre water) can be used to spray onto equipment. It is very effective because of its fumigating action, but unpleasant to work with. Workers should use a respirator when disinfecting the packhouse. Formaldehyde is also very suitable for the fumigation of cold storage rooms. Use approximately 5 ml per cubic metre and treat for 24 hours or mix 4 g potassium permanganate ($KMnO_4$) and 20 ml formalin for every one cubic metre space and fumigate for at least 4 hours.

5.3 Sodium orthophenylphenate (SOPP, Dowicide A, Preventol ON Extra)

Use as a 1% concentration (no adjustment of pH necessary) to wipe equipment and clean brushes; follow up with clean water rinse.

5.4 Captab (Kaptan, Orthocide, Merpan)

Use as a 5% concentration, i.e. 500 mg active ingredient per 100 ml water. Wipe or spray onto equipment and floor.

6 PREVENTION OF RESISTANCE TO POST-HARVEST FUNGICIDES

A small percentage, normally less than 1%, of any fungal spore population is resistant to one or more of the post-harvest fungicides currently registered. The manner in which post-harvest fungicides are applied and the handling and storage of fungicide treated fruit will determine whether the resistant spores increase until eventually they form the majority of the spore population, thus rendering our post-harvest treatments ineffective.

6.1 How does fungicide resistance develop?

Selection pressure is the main reason for fungicide resistance. In other words, the intensive use of any fungicide or fungicides with the same type of action selectively inhibits the sensitive spores in any fungal population, thus allowing the resistant spores to multiply unimpeded.

6.2 How did TBZ resistance develop?

Thiabendazole (TBZ) belongs to the benzimidazole group of fungicides, which all have the same type of action. Members of this group include TBZ (TECTO®), benomyl (BENLATE®), thiophanate-methyl (TOPSIN® M) and carbendazim (BAVISTIN®).

The benzimidazoles (other than TBZ) had been used intensively in the form of pre-harvest sprays of orchards for the control of blackspot for many years. Thus the benzimidazole resistant green and blue mould spore population, which occurred naturally, were exposed to selection pressure as follows: Poor orchard sanitation or hygiene led to millions of spores being present on fruit surfaces. Poor insect control caused rind injuries which were infected with many spores, most of which were suppressed by the benzimidazole residues in the fruit rind.

However, this did not prevent them from contributing to decay caused by a small percentage of benzimidazole resistant spores which, in turn, led to millions of additional resistant spores. Once the harvested fruit, laden with more resistant spores, were taken into the packhouse, TBZ was applied, which led to a further selective inhibiting of sensitive spores and by allowing that TBZ treated fruit to develop decay in and around the packhouse, millions more resistant spores were released. The cycle continued until the majority of the spore population were resistant to TBZ and the benzimidazoles. At this stage the packhouse fungicide treatment became totally ineffective.

6.3 Strategies to prevent a resistance problem

The post-harvest fungicides registered for use in

South Africa, i.e. guazatine, imazalil, sodium orthophenylphenate and thiabendazole, each have their specific mode of action. Until now resistance against TBZ has been found in some areas only. Effective post-harvest decay control in the packhouse should therefore be possible by applying the following strategies:

6.3.1 Pre-harvest disease control

It is not advisable to use fungicides with the same type of action for both pre- and post-harvest disease control (See above).

6.3.2 Orchard hygiene

To cause fruit decay, fungal spores in a wound should reach a certain threshold concentration. Normally the natural environment does not contain sufficient fungicide resistant spores for this threshold to be reached. It has been proved, however, that fungicide sensitive spores could assist small quantities of fungicide resistant spores in causing fruit decay. It is therefore essential to keep the total spore load on the fruit as low as possible.

Fallen fruit should therefore be removed from the orchard twice a week, before fungal spores can form on the surface of the fruit.

6.3.3 Insect control

Fruit-attacking insects should be controlled to prevent stings which serve as points of entry for blue and green mould fungi as well as the sour rot fungus.

6.3.4 Chlorination of dump tanks and washing of fruit

To further reduce the spore load on fruit surfaces, the water in the dump tank should be thoroughly chlorinated. Where fruit is dry dumped, contamination of the first set of brushes should be avoided by preventing spores from the surface of the fruit accumulating on these brushes and serving as a source of infection. Fruit must be washed with a fungicide-containing disinfectant (e.g. Deccosol) or chlorine, or should be rinsed with chlorinated water.

6.3.5 Immediate treatment of fruit after picking

To prevent sporulation of green and blue mould on fruit in lug boxes or trailers, fruit should be treated immediately after picking. This will prevent fruit carrying a high spore load from entering the packhouse.

6.3.6 Use of fungicide mixtures

Where no resistance has been recorded against any of the components of a fungicide mixture, using fungicide mixtures with different modes of action will considerably delay resistance problems. No resistance has been observed against guazatine, imazalil and sodium orthophenylphenate (SOPP) in South Africa to date. Incidences of TBZ resistant strains of blue and green mould have been isolated in most production areas.

6.3.7 Alternation of fungicides

It has been established that the biotypes of green mould showing resistance to imazalil or TBZ cannot successfully compete with fungicide sensitive biotypes in the absence of the fungicide concerned and that gradual reduction in the number of resistant bio-types will occur while such fungicide is withheld from use.

The above phenomenon makes it possible to continue using a certain fungicide effectively, even in the presence of resistant strains or pathogens, withdrawing that specific fungicide and replacing it by a fungicide with a different mode of action until the total number of resistant spores is very low or undetectable, at which stage the fungicide originally used is brought in again to replace the second fungicide. This cycle is then repeated.

The above does not apply to all forms of resistance and every pathogen-fungicide interaction should be evaluated on its own

6.3.8 Sanitation in the packhouse

Sporulation on fungicide-treated fruit in the

packhouse should be avoided at any cost. Local market fruit should be stored in another building; factory fruit should be removed regularly and fungicide-treated culled fruit should be destroyed before spores can be formed on such fruit.

Do not repack fruit rejected for decay at the ports at inland packhouses. Where decayed fungicide- treated fruit is repacked at an inland packhouse, the entire packhouse should be thoroughly sanitized with formaldehyde immediately after repacking has been completed or every night, whichever is sooner.

7 COOLING OF FRUIT

The importance of refrigeration to assist in controlling post-harvest decay cannot be over-emphasised. Low temperatures not only delay or stop the development of fungi, but the physiological post-harvest life of citrus fruit will also be maximised by keeping it at the minimum temperature tolerated by the citrus variety concerned.

It is senseless to adhere strictly to the recommendations for post-harvest control and then delay cooling of the fruit or ship the fruit at temperatures that allow rapid fungal development. Delayed precooling after packing has proved to be the single most important reason for high waste figures in overseas markets, with inadequate precooling the second most important.

All packed fruit must be delivered to the ports within protocol for precooling to the ideal shipping temperature. This period may be shorter for certain mandarin types or during seasons when certain varieties show a high waste potential.