Postharvest decay control

— fungicides and sanitisers

By John Golding and SP Singh

Key points

- Tips to manage mould and sour rot
- Postharvest fungicide options
- Sanitiser use essential

THE development of rots and decay after harvest is a serious problem, particularly on fruit destined for export markets that may be stored and transported over many weeks. The major postharvest rots that develop on citrus are green and blue mould (caused by the fungus *Penicillium*) and sour rot (caused by *Galactomyces citri-aurantii*).

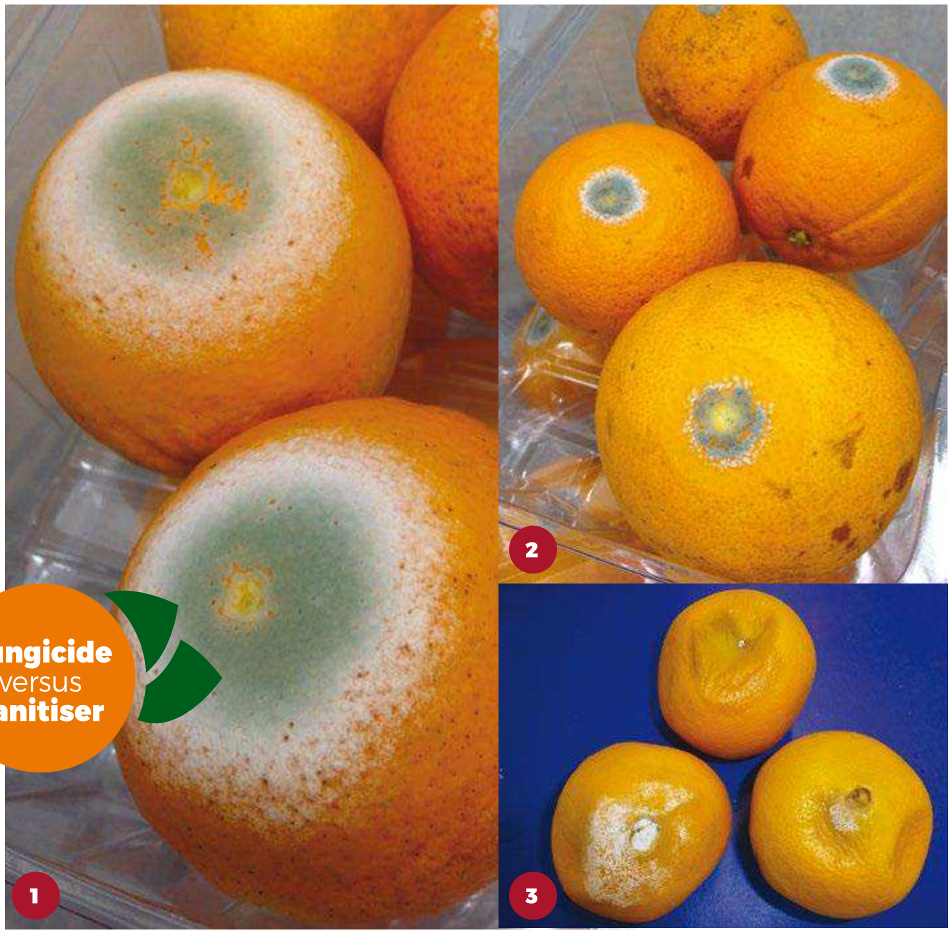
The control of all decay after harvest requires an integrated approach:

1. Harvest and handle fruit to minimise physical injuries such as punctures, abrasions and cuts, as many rots rely on damage (wounds) to the skin for entry and infection.
2. Maintain hygiene and sanitation within the packing shed and keep fungi out of the packing shed and coolrooms to reduce the risk of decay.
3. Use sanitisers in the washwater and on the packing line.
4. Use appropriate fungicides and follow the label instructions.
5. Keep the fruit in the coolroom.
6. Monitor the levels of spores and fungicide resistance in the packing shed and develop a strategy to manage them effectively.

Each of these different management steps is critical to managing postharvest decay. This article will focus on the successful use of sanitisers and fungicides to control decay during storage.

Fungicide versus sanitiser

Fungicides control fungi (e.g. blue and green mould), including during storage, due to their residual effect, with each fungicide controlling a specific decay. Sanitisers are not specific and control



Postharvest decays such as green mould (1), blue mould (2), and sour rot (3), and can be managed with fungicides and sanitisers.

fungi, bacteria and yeasts. Sanitisers are essential for food safety and kill pathogens in water on contact, but once they are inactivated there is no residual protection.

Current postharvest fungicides

Many packers have been using the same postharvest fungicides for many years but there is a range of postharvest fungicides available. Table 1 provides a list of chemicals that are registered for use in Australia.

For exporters, it is critical that all postharvest chemicals are accepted in the planned export market, because many overseas countries have different restrictions on fungicides. For example, guazatine is not allowed in some export

Fungicide bin drench of freshly harvested oranges.

markets and cannot be used. Growers should consult the most recent maximum residue limits (MRL) tables for each market, which are available on the Citrus Australia website and produced through the levy-funded project *MRL risk analyses and risk management options for major*

TABLE 1 Registered chemicals for postharvest control of green and blue mould and sour rot

Active ingredient	Examples of trade names[1]	Class of fungicide	Group of fungicide	Controls other pathogens
Green and blue mould				
Thiabendazole (TBZ)	Vorlon®, Tecto®	Benzimidazole Group	1	Stem end rot, *Phomopsis citri*
Imazalil	Magnate®, Fungaflor®	DMI Group (Demethylation Inhibitors) (Imidazole)	3	
Imazalil + Pyrimthanil	Philabuster®	DMI and Anilinopyrimidine Group	3 + 9	
Fludioxonil	Scholar®	Phenylpyrrole Group	12	Diplodia Stem end rot
Guazatine[2]	Zanoctine®, Panoctine®	Multi-site activity (Guanidine)	M7	Sour rot
Sodium ortho-phenylphenate (SOPP)	Preventol® ON Fungicide			Blue mould only
Sour rot				
Guazatine[2]	Zanoctine®, Panoctine®	Multi-site activity (Guanidine)	M7	Green and Blue mould

* These chemicals are registered for use as at August 2017. Visit the APVMA website to check their registration and use in each state (https://portal.apvma.gov.au/pubcris).
It is critical to check that these chemicals are allowed in certain export markets.
[1] Other trade names exist.
[2] Check that this is registered in your state/territory.

citrus export markets (CT14003), under the Hort Innovation Citrus Fund.

The successful use of postharvest fungicides relies on having an integrated approach to decay control, using all tools to minimise rot (such as hygiene), and always reading and following the chemical label because poor use of fungicides can lead to excessive residues in fruit or the development of chemical-resistant fungi.

Sanitisers

Pretreating or washing fruit with water containing a sanitiser is essential to minimise the risk of bacterial pathogens and reduce fungal spores. Citrus fruit are generally not considered a carrier of foodborne pathogens (e.g. Salmonella) due to their high acidity and inedible rind. However, recent research has shown that bacterial pathogens present on citrus rind may be transferred to the hands and mouths of consumers during peeling and eating. Therefore, the use of a sanitiser is important to reduce food safety risks and to complement fungicide use.

A number of sanitisers with different chemistries are currently available in the market and are registered with the APVMA.

Each sanitiser has its own merits and demerits of adoption. Factors that influence which sanitiser to choose include price, water source (channel, ground or council), water quality (pH, hardness), packing line machinery (corrosiveness), buyer's requirement, method of application and monitoring (manual versus automatic) etc. Always follow the label guidelines and manufacturer's instructions to ensure correct and safe use of sanitisers at recommended concentrations and conditions.

Chlorine

Chlorine has been a very popular sanitiser for years. Chlorine-based sanitisers include sodium hypochlorite, calcium hypochlorite, bromo-chloro-dimethylhydantoins and chlorine dioxide.

For the effective use of sodium and calcium hypochlorites, an understanding of the basic chemistry of chlorine is key to managing its active concentration in wash water. When chlorine is dissolved in/added to water, it dissociates into hypochlorous acid and hypochlorite ions, depending on the pH of the water. The hypochlorous acid is the most active form and having a higher proportion of it over hypochlorite ions is required for proper sanitation. A pH range of 6.5 to 7.0 is optimal to achieve higher concentration of hypochlorous acid, while a pH of 7.5 or more results in more hypocholorite ions.

If wash water is alkaline (pH >7.0), the addition of chlorine will further increase the pH, leading to poor antimicrobial efficacy of the chlorine present in water. This will require the addition of hydrochloric acid to decrease the pH to 6.5–7.5 for chlorine to be effective. A low pH (<5.0) combined with a high water temperature will lead to the release of poisonous chlorine gas from chlorinated water which is an occupational health hazard for workers. In a nutshell, the pH of the wash water after the addition of chlorine should be maintained between pH 6.5 and 7.5.

The use of chlorine in wash water requires more effort and management to monitor the pH, chlorine concentration and sanitation potential of water. In addition to the pH, organic load also affects the efficacy of chlorine because active chlorine is neutralised by debris and dirt present in water. Chlorine concentration and pH can be monitored using paper test strips available from chemical suppliers, but digital equipment is more accurate and objective. Another indirect measure of the sanitising capacity of water is oxidation-reduction potential (ORP), which can be measured using an ORP probe. An ORP reading of more than 700mV suggests acceptable levels of sanitation potential. However, the ORP reading should be interpreted along with wash water pH and proper chlorine concentration. Some companies supply

A multi-probe meter can determine the pH and other characteristics of wash water.

a digital meter with two or more probes to measure pH and ORP simultaneously. These monitoring tools are not expensive and are highly recommended for packing sheds to enable the accurate measuring and recording of data.

Bromo-chloro-dimethyl hydantoins (BCDH) are another option as a sanitiser registered with APVMA. These sanitisers also provide broad-spectrum control of microbial pathogens.

They represent a unique blend of chlorine and bromine chemistries which provide sanitising activity in a broad pH range, especially towards alkaline conditions (7.0 to 8.5). The basic chemistry of bromine in water is quite similar to chlorine, except the active form of bromine (hypobromous acid) predominates until 8.5, as opposed to 7.5 for chlorine. It is also less affected by organic load compared to chlorine and relatively lower concentrations are required.

Chlorine dioxide is another form of chlorine sanitiser which is currently available in different formulations with a stabilised active ingredient. Because of its very high reactivity and low concentration (up to 10 parts per million, or ppm), less contact time is required for wash water treatment.

It is effective against bacteria, moulds and yeast over a pH range up to 8.5. Organic matter in water does not affect the efficacy of chlorine dioxide.

Other sanitisers

There is a shift towards peracetic acid (PAA)-based sanitisers, which is driven by the environmental impacts of chlorine byproducts and management issues associated with chlorine. PAA is very reactive and quickly decomposes to oxygen, water and acetic acid (the acid in vinegar).

The use of PAA at the recommended concentration (up to 80ppm) is effective in reducing microbial load and achieving product sanitation. Unlike chlorine, it is effective over a wide range of pH and requires less management. However, the effective monitoring and recording of PAA concentrations in wash water is critical, as for any other sanitiser, and can be done using test strips. PAA is corrosive and measures to protect machinery and workers should be taken if it is used.

Iodine is an effective sanitiser for water treatment. It can be used over a wide range of pH and the water's organic load does not affect it greatly.

Iodine has limited availability for this type of use, is corrosive to metals and is expensive, but some packing sheds are successfully using it.

Ozone is a gaseous sanitiser which can be dissolved in wash water by generating it on-site using an ozone generator. Ozone is very effective at killing microbial pathogens over a wide range of pH but it also reacts with organic matter. However, it is highly corrosive, with potential risks to workers' health and safety, but it has been used successfully in some packing sheds.

Considering consumers' sensitivity and the environmental impacts of chemical residues, Hort Innovation and the NSW Department of Primary Industries have co-funded a project which is aimed at developing cold plasma as a new decontamination technology whose treatment time is short and which leaves no residue on produce.

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MORE INFORMATION

Visit the project website: www.coldplasma.net.au

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