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Degreening of citrus

Peter Taverner
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Many citrus cultivars can be quite palatable while their peel colour is still green. The consumer associate green with immaturity and the use of ethylene to 'degreen' is a legitimate method to improve the visual quality of, otherwise, mature fruit.

Ethylene effects on citrus colouring

Ethylene is a natural growth regulator produced by most fruits as a response to stress and during the natural aging process. Ethylene does not ripen citrus fruits. As such, the acid, sugars and flavour of the juice are unaffected by ethylene exposure. However, ethylene does destroy chlorophyll, and promote the development of yellow and orange colour in the rind. Under conditions of mild stress, such as cold nights, citrus degreen naturally. The postharvest use of ethylene seeks to chemically hasten the degreening process.

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Ethylene effects on decay

Ethylene promotes senescence (aging), which increases the susceptibility of citrus to decay. The temperature (typically, 22º to 24º C) and high humidity (ideally, 95% RH) required for ethylene degreening also provides ideal conditions for the development of postharvest disease. Ethylene accelerates senescence of the fruit calyx, which favours 'stem-end rots' (eg. *Diplodia natalensis, Phomopsis citri* and *Alternaria citri*). Dipping citrus in 2,4-D before gas colouring assists in retaining green colour and 'freshness' in the calyx. The effect can vary with different cultivars, with Navel oranges responding well, and lemons the best to 2,4-D dipping. The label rate can be as high as 500ppm in a postharvest drench, but high rates of 2,4-D may inhibit colouring. Lower rates may be justified as some cultivars, such as tangelos, are very sensitive. In some overseas countries, 2,4-D rates of 15ppm are used on easy peel citrus prior to degreening.

Ethylene can also lead to an increase in anthracnose decay (*Colletotrichum gloeosporiodes*). The level of ethylene used in degreening is considered important. Ethylene levels above 5 ppm do not hasten degreening or improve colour, but may cause serious losses from anthracnose disease.

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Degreening practices

Citrus fruit require some colour break prior to harvest for effective degreening. Early season Navels oranges should be showing at least one third natural colour before degreening. Fruit harvested when the trees are suffering from lack of water, are prone to wilting and losing buttons during degreening. Full colour will not develop on fruit recently sprayed with oil.

The harvested fruit are usually treated with a fungicide prior to placing in degreening rooms or under plastic tents. High humidity can be achieved by placing fruit straight into degreening rooms after bulk dipping. However, wet fruit should not be placed into degreening if the humidity in the room is already high (95% RH) and there is a risk of 'free' water remaining on the fruit.

The 'shot' method was commonly used before the development of trickling ethylene. Fruit is enclosed in an airtight room and exposed to a measured amount of ethylene for 6-14 hours. The accumulation of carbon dioxide in rooms over time is a problem with this method. High carbon dioxide levels (above 1%) inhibit the degreening process. The room must be regularly ventilated and the entire process repeated until the fruit is coloured.

The 'trickle' method is the most common method to apply ethylene. This involves continually replacing the air in the degreening area with a low concentration of ethylene. The concentration of ethylene is usually around 5ppm, and should seldom exceed 10ppm. Efficient airflow and ventilation facilitates uniform distribution of the ethylene and removes accumulated carbon dioxide. The common air ventilation recommendation of one room volume per hour is empirical, but its success is related to good room design and automated humidity control (Wardowski*et. al*. 2006). Gillespie and Tugwell (1975) recommended very similar ventilation rates of 2% of room volume per minute. The most undesirable effect of degreening under low humidity is fruit softening, and exacerbation of injuries and rind weaknesses.

Ethylene phytotoxicity

Excess rates of ethylene may produce rind damage or'gas burn'. Some citrus cultivars are more sensitive to ethylene damage. Degreening can be done with small fruit samples early in the season to determine tolerance to degreening. This is important with early-maturing mandarin-type fruit, where degreening for longer than 36 hours can greatly increase the risk of breakdown. To reduce the risk to sensitive varieties, the fruit can be allowed to 'degas' after ethylene treatment and prior to waxing. Alternatively, fruit can be exposed to ethylene for shorter periods (6-12 hours) before transferring into high humidity rooms (without ethylene) until acceptable colour development (Petracek *et. al* 2006).

Safety notes

Ethylene, used in the quantities required for degreening is not flammable, but it does form an explosive mixture at higher concentrations (above 3% by volume). Regardless, keep flames away from degreening rooms, and ground all pipes to prevent electrostatic discharge. Degreening rooms should be fitted with safety cut-off values in case of power failure. Some ethylene monitoring equipment will include alarm systems. Gas cylinders, regulators and lines should be checked for leaks and calibrated for correct operation. Solid walls should be fitted with an explosion port (small 'blast' door) as a safety measure. Thorough ventilation should be carried out before anyone enters after any type of ventilation breakdown or where poor ventilation is suspected.

References and further reading

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Tips for postharvest Anthracnose control in citrus

By Peter Taverner, SARDI

Anthracnose is a sporadic disease, which may be why there isn't a postharvest fungicides registered for its control in citrus. We conducted work, early in 2000, evaluating the fungicides available at that time to see if any gave some control. Fortunately, there are postharvest fungicides available that gave reasonable control of anthracnose despite the lack of label claims. The results of that work and a detailed description of anthracnose is in Packer Newsletter 71. Article obtained at the following website address; http://www.sardi.sa.gov.au/__data/assets/pdf_file/0020/45146/packnews71.pdf.

Since this work, there have been other developments. Scholar® (fludioxonil) has recently been registered for postharvest use in citrus; it also has reasonable activity against anthracnose. Initially, its use was limited because Japan had a MRL of 1ppm for oranges. More recently, Japan has revised the MRL in accord with Codex and most other countries (at 10ppm MRL). This greatly increases the usefulness of this chemical. Information on MRLs obtained at the following website address; http://www.m5.ws001.squarestart.ne.jp/foundation/agrdtl.php?a_inq=62600

In summary, the best control of anthracnose can be achieved by a combination of in-field and postharvest treatments.

- ✓ The fungus responsible for anthracnose harbours in deadwood. Good cultural practices to reduce deadwood should be encouraged.
- ✓ Field sprays of copper-based fungicides or Mancozeb® may inhibit spore germination. Heavy rain may wash off a copper application and allow infection. There is also an emergency permit use for iprodione and azoxystrobin in Queensland. Tips on the use of these fungicides can be found in Andrew Miles' (DEEDI) article entitled "Tips for the emergency use of iprodione and Amistar®". The article can be obtained at the following website: http://www.citrusaustralia.com.au/latest-news/emergency-use-permits-achieved-for-two-new-fungicides
- ✓ Ethylene stimulates anthracnose development. Delayed harvesting or selective picking for better colour will minimise the amount of time in degreening.
- ✓ Ethylene degreening should not be above optimal concentrations (5ppm -trickle method).
- ✓ Harvested fruit should be washed on revolving brushes to remove appressoria or dipped in a thiabendazole fungicide (e.g., Tecto®) to control anthracnose before degreening.

NB. Dipping in guazatine alone will not control anthracnose. Fruit treated with guazatine and a benzimidazole will control moulds, sour rot and anthracnose.

- ✓ If disease pressure is high, a combination of two different fungicides with activity against anthracnose, i.e., thiabendazole (Tecto®) and fludioxonil (Scholar®), should provide superior protection.

NB. Dipping in thiabendazole and fludioxonil will not control sour rot.

- ✓ Immediate cold storage of fruit after packing may assist in reducing the expression of anthracnose.✯

Sodium o-phenylphenate tetrahydrate (SOPP).

Peter Taverner

SARDI

This article was prompted by a trip to Queensland, where SOPP is used on citrus. I must admit that SOPP is a mysterious chemical to me. I know that pH and temperature are important and if you get it wrong it 'burns' the fruit. It is an 'old-timers' chemical but it continues to be used successfully by experienced packers. I have had no direct experience myself in its use and rely heavily on references for the information in this article.

In Australia, Preventol® ON (950g/kg sodium ortho-phenylphenate tetrahydrate) is register as a dip for post harvest treatment of citrus. The label also suggests that a 2% solution can be used to disinfect floors, walls and equipment. However, rinse it off because it can be corrosive to metals.

If you are interested in "how it works" read on. Otherwise, skip to the practical use parts later in this article.

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SOPP in water

After a bit of research; I'm starting to like SOPP. When dissolved in water, SOPP establishes an equilibrium between the dissociated o-phenylphenate (OPP^- anion) and un-disassociated o-phenylphenol (HOPP) forms (see figure 1, below). The concentrations of each form are dependent on the overall concentration of SOPP and the pH of the solution. In that sense, it is similar to sodium hypochlorite (which is also forms a pH-dependant equilibrium).

The HOPP form is very active against microbes, but it also causes fruit injury at around 200-400ppm, depending on the temperature of the solution and contact time. The OPP^- anion (on the other side of the equilibrium) is much less injurious to rind.

SOPP use on citrus requires the pH to be increased to suppress the amount of HOPP, and thereby, reduce the risk of rind damage. The principle cause of fruit damage is a drop in the pH of the SOPP solution due to dilution with fresh water or gradual acidification by fruit debris, CO_2 and soil.

However, HOPP is still required, because it is more active against microbes. Fortunately, HOPP magically accumulates in rind injuries, where it is most needed (actually, it only seems like magic – read on!)

SOPP in fruit injuries

The intact waxy surface of citrus is practically resistant to the absorption of the OPP^- anion. HOPP penetrates into the fruit rind and fungal cells more readily but there should only be small amounts present in solution to reduce the risk of rind injury.

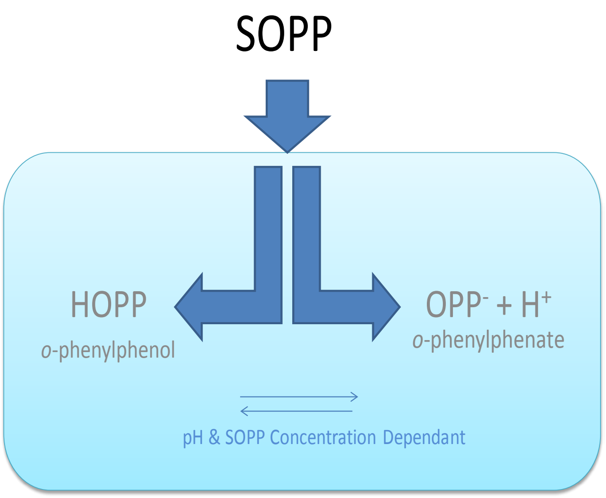

Figure 1 SOPP dissolves in water and establishes the equilibrium between HOPP and OOP.

However, the OPP^- anion does readily diffuse into rind wounds. The environment in wounds is acidic due to the presence of fruit acids, which then converts the OPP^- anion into the HOPP form. In this way, the active form accumulates in the wounds, where it is needed. The fruit are usually rinsed to remove the SOPP residues from the surface but some HOPP deposits remain in the wounds, providing protection during storage.

In summary, SOPP protects in two ways; it removes or kills spores on the fruit surface, and provides some residual protection in wounds during storage.

SOPP protection

SOPP is considered more effective in controlling decay on oranges than grapefruit or mandarin varieties. It is effective against Blue and Green mould, and provides some protection against Sour rot, Diplodia stem end rot and Alternaria stem-end rot. However, it is only weakly effective against Anthracnose during long storage.

SOPP is not compatible with imazalil sulphate or with EC formulations in excess of 100ppm imazalil.

SOPP application

Traditionally, fruit were immersed in SOPP baths. This type of use was more common 20 years ago but in many places, such as California, SOPP has replaced by carbonate salts. There is not a lot of information on current use and the most detailed description of immersing fruit in SOPP is from South Africa. A modified summary follows:

<u>Precautions when using SOPP</u>

- Fruit picked early in the morning or turgid fruit should be wilted 12-24 hours before immersion in SOPP. Lemons are especially sensitive.
- Immersion time should not exceed 3 minutes and should be controlled by use of submegers or paddles.
- Concentration of SOPP at different temperatures should be determined accurately.
- Control of pH is very important; too low pH can lead to serious burning of fruit.

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- Temperature should be well controlled; too higher temperature, coupled with high concentrations, will burn fruit.
- Fruit should be rinsed with fresh water after immersion in SOPP.

<u>SOPP dip treatment options</u>

- 0.15% SOPP @ 47ºC max.

  Maintain pH between 10.7 and 11.0 by addition of sodium hydroxide (caustic soda). This treatment is favoured when heating is used to detect insect stings.

- 0.5% SOPP @ 32ºC to 40.5ºC

  Maintain pH between 11.7 and 12.0 by addition of sodium hydroxide (caustic soda).

- 1.5% SOPP @ 32ºC or less

  Maintain pH between 11.7 and 12.0 by addition of sodium hydroxide (caustic soda).

  Nb. Hexamine is added to SOPP in South Africa to help buffer the pH within the appropriate range. However, hexamine is not classified as a food additive in Australia.

In other countries, SOPP has been mixed with foam cleaners and applied as a foam curtain dropping over moving fruit or sprayed onto brushes as a wash, with the action of the brushes causing foaming. This treatment is usually applied for 10-30 seconds before a fresh water rinse. The foam treatment is less effective at decay control than the SOPP bath but there is less risk of injury and pH control in not an issue because the foam is not re-cycled.

Standard practice is to follow a SOPP treatment with another separate fungicide treatment. In some countries, ~1% SOPP can be incorporated in wax as an additional treatment.

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