POST-HARVEST TREATMENT WITH OZONE FOR THE CONTROL OF RIPE ROTS IN AVOCADO

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ABSTRACT

Ozone is a powerful oxidising agent, which can kill micro-organisms if they are exposed to a high enough dosage for a sufficient period of time. Two trials were conducted to determine if ozone has the potential to reduce viable spore loading and latent infections on the surface of Hass avocados, thereby reducing the level of rots in ripe fruit. Trial 1 was held at the end of the 1999-2000 season. Rot incidence and severity in this trial was uniformly high, with no significant treatment effects. The trial was repeated in the 2000-2001 season (Trial 2), when disease pressure was lower. In both trials there were three treatments, a water dipped control and two durations of ozone exposure. Fruit were submerged in ozone-enriched water. Both durations of ozone treatment in Trial 2 significantly reduced the severity of body rots. The shorter duration treatment significantly reduced the severity of stem-end rots. However, neither treatment provided a significant reduction in incidence of either body or stem-end rots.

Keywords: ozone, post-harvest treatment, stem-end rots, body rots

INTRODUCTION

Ozone has been used for almost a century as a means of disinfection predominantly for water supplies. In Europe, especially France and Germany, ozone has been the primary sanitizer for public water systems and there has been widespread adoption of ozone as a wastewater treatment.

The effectiveness of ozone as a sanitizing agent lies in its ability to kill micro-organisms by oxidation of cell membranes. As an oxidizing agent, ozone is one and a half times more powerful than chlorine (Xu, 1999).

Ozone has a number of features that make it ideally suited as a post-harvest treatment. It decays very rapidly into oxygen leaving no residues and has a half-life of 20 minutes in water a room temperature (Graham, 1997). Ozone can also destroy chemical residues on the fruit surface (Langlais et al, 1991) and it has also been demonstrated to effectively reduce post-harvest losses during storage for several crops (Xu, 1999). In addition, ozone has also been demonstrated to induce defence responses within plant tissues (Kangasjarvi et al, 1994)

A series of trials were conducted to investigate the feasibility of controlling ripe rots in avocado with a post-harvest treatment of ozone. This included an examination of any detrimental physiological effects that might result from ozone treatment including changes in fruit firmness, rate of ripening and fruit damage.

MATERIAL AND METHODS

Trial 1

In the first trial carried out in May 2000, three treatments were used. These were:

1) 1 minute dip in water (control)
2) 1 minute dip in 0.1 mg/L ozone (Ct value = 0.1)
3) 5 minute dip in 0.1 mg/L ozone (Ct value = 0.5)

Trial fruit was obtained from a single orchard, after it had been picked and graded. Fruit were randomly allocated in to treatment replicates of 50 fruit. Each replicate was dipped in to a vessel containing 80 litres of water with a total of 250 fruit per treatment. Ozone was supplied via a portable generator. Concentration of ozone in the dipping solution was checked at regular intervals using a colorimetric test kit. The concentration of ozone varied between replicates but was maintained in the range of 0.07 – 0.10 mg/L for the majority of replicates.

Trial 2

The trial was repeated in May 2001. In this trial, the average ozone concentration obtained over the course of the experiment was 0.5 mg/L. Concentration of ozone in the dipping solution was checked at regular intervals using a colorimetric test kit. Dipping times were extended to increase Ct values. The treatments were:

1) 5 minute dip in water (control)
2) 5 minute dip in 0.5 mg/L ozone (Ct value = 2.5)
3) 30 minute dip in 0.5 mg/L ozone (Ct value = 15)

A total of 270 fruit per treatment were dipped. Fruit were randomly allocated to each treatment, which was replicated 3 times with 90 fruit per replicate. Fruit were dipped and stored in F40 crates.

Fruit from both trials were coolstored at 5 – 7 °C for either 3 weeks (Trial 1) or 4 weeks (Trial 2), removed from coolstorage and ripened at 20 °C. Fruit quality was assessed daily for the development of rots. Ripe fruit quality was assessed when individual fruit reached a hand firmness value of 90-100 based on a firmometer with a 300g weight. Fruit were assessed according to the AIC Fruit Assessment Manual.

RESULTS

Trial 1

There were no significant treatment effects in the first trial. However, the disease pressure was very high, with over 95% of the control fruit developing body rots, and over 70% developing stem-end rots (Table 1). The Ct values attained were also much lower than anticipated as the concentration achieved was considerably less than the target concentration of 2 mg/L. It was not possible to achieve ozone concentrations higher than 0.25 mg/L ozone with the available equipment and the quality of the water supply (bore water).

Trial 2

The overall severity of rots was relatively low in Trial 2 (Table 2). However, there were several significant effects as a result of treating fruit with ozone. Fruit dipped in an ozone solution for 5 minutes significantly reduced the severity of stem-end rots compared with the control. Both ozone treatments also reduced the severity of body rots but not the incidence.

Table 1. Results of Trial 1.

	Severity (%)		Incidence (%)	
Treatment	Stem-end rots	Body rots	Stem-end rots	Body rots
1	0.74	28.8	72.4	94.9
2	0.72	33.4	71.9	91.8
3	0.79	29.6	71.8	93.2

Table 2. Results of Trial 2.

				Severity (%)		Incidence (%)	
Treatment	Days to ripen	Firmness	Colour	Stem-end rots	Body rots	Stem-end rots	Body rots
1	4.9 a	95.0 a	83.7 a	0.20 a	2.10 a	29.6 a,b	41.9 a
2	5.0 a	94.7 a	83.4 a	0.10 b	1.11 b	22.6 a	33.1 a
3	5.0 a	96.8 b	83.7 a	0.26 a	1.14 b	35.1 b	36.6 a

Values within a column followed by the same letter are not significantly different ($P<0.05$).

Fruit that were dipped in an ozone solution for 5 minutes had significantly fewer stem-end rots (incidence) than those dipped for 30 minutes, but not compared with the control. This suggests that dipping the fruit for too long may be detrimental to fruit quality. This is supported by the fact that fruit dipped for 30 minutes had significantly worse severity of stem end rots than those dipped for 5 minutes. The fruit dipped for 30 minutes were also slightly softer than the other two treatments when assessed. We cannot determine from this experiment if this was due to the longer exposure to ozone, or simply the longer dipping time in water. To answer this question would require a second control dipped in water for 30 minutes.

There was no apparent influence of either of the ozone treatments on the ripening behaviour of the fruit. Ripening times and colour were not significantly different from the control in Trial 2. There was no indication of any adverse effects of ozone treatment on the external appearance of the fruit in either of the trials.

DISCUSSION

It was not possible to achieve the target concentrations of ozone in either of the experiments. This highlights some of the practical difficulties with the use of ozone, including stripping by organic matter, and dependence on water conditions, including oxygen concentrations and temperature. Organic matter reacts readily with ozone dramatically reducing its sanitizing power. The accumulation of debris, surface contaminants and other organic matter will strip the amount of ozone available to attack the target organism. To some extent this can be compensated for by longer exposure times, which may not be practicable in a commercial situation.

Despite these limitations it was possible to obtain limited control of rots in Trial 2. However, ozone treatment only reduced the severity of rots, it did not reduce the incidence of either stem-end rots or body rots. This would suggest that it has not been effective at killing off fungal propagules or latent infections on the fruit surface.

Ozone is far less effective in decontaminating food surfaces than food-contact or equipment surfaces (Kim et al, 1999), possibly as a result of exposure to organic matter other than the target micro-organisms. Some studies (Ogawa et al, 1990; Spott and Cervantes, 1992) have shown that where the micro-organism is attached or embedded in the fruit surface or other organic matter then the effect of ozone treatment is significantly reduced. This has been attributed to the ozone reacting with the plant tissue and extracellular biochemicals at a wound site.

Ogawa et al 1990 found that ozone treatment of tomatoes did not control *Botrytis* when the spores were embedded in the tomato surface. Increasing the duration of ozone exposure did not increase effectiveness of the treatment.

SUMMARY

In these trials, while it has been demonstrated that ozone has the potential to reduce rots when disease pressure is low, the actual reductions achieved are unlikely to be commercially significant. Further there may be detrimental effects from a long exposure period, but this requires more experimentation.

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