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# NOTE

# REDUCTION OF CHILLING INJURY IN SWEET LIME BY THIABENDAZOLE AND BENOMYL DURING COLD STORAGE

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## ABSTRACT

Preharvest spray of benomyl significantly reduced chilling injury (CI) in sweet lime (*Citrus limetta* Swing.) as expressed by peel pitting, but thiabendazole (TBZ) was not effective. Postharvest dipping of fruits in water suspensions containing benomyl or TBZ reduced CI, but TBZ was more effective than benomyl. The effectiveness of both postharvest TBZ and benomyl treatments increased when followed by waxing. The tendency of both TBZ and benomyl in CI reduction was decreased by increasing their concentrations.

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# کاهش سرمازدگی لیموشیرین در سردخانه توسط تیابندازول و بنومیل

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## چکیده

در حالیکه محلول پاشی قبل از برداشت لیموشیرین (*Citrus limetta* Swing.) با بنومیل بطور قابل ملاحظه‌ای از سرمازدگی که علائم آن ظهور لکه‌هایی روی پوست می‌باشد جلوگیری نمود، تیابندازول اثری نداشت. غوطه‌ور کردن میوه‌ها بعد از برداشت در محلول تیابندازول و یا بنومیل سرمازدگی را کاهش داد و تیابندازول از بنومیل مؤثرتر بود. افزایش غلظت بنومیل و تیابندازول در تیمارهای بعد از برداشت، باعث کاهش اثر آنها در جلوگیری از سرمازدگی گردید.

## INTRODUCTION

Sweet lime is one of the most chilling sensitive of the citrus fruits and is mostly harvested before winter to avoid chilling injury (CI). Due to susceptibility of sweet lime fruits to low temperature, a relatively high storage temperature of 1°C is recommended (7).

Thiabendazole (TBZ) and benomyl have been used for postharvest decay control of citrus fruits (1, 2, 4). Besides their fungicidal action, they can be used on grapefruits during storage to reduce CI (3, 8, 10). So far no work has been done in this respect on sweet lime. The purpose of this study was to evaluate the effects of preharvest and postharvest application

of TBZ and benomyl on chilling injury in sweet lime and to speculate on their mode of action.

## MATERIALS AND METHODS

### Preharvest Treatments

The fruits on branches of ten year-old sweet lime trees were sprayed with 3000 and 6000 ppm active ingredient (a.i.) of thiabendazole and benomyl on Dec. 8, 1990. The fruits were harvested on Dec. 15, 1990. Harvested fruits from each treatment were transferred to the laboratory of the College of Agriculture, Shiraz University. On the next day, harvested fruits of each treatment were divided into random samples of 5 fruits using a completely randomized design with three replications and kept in perforated polyethylene bags and stored at 3 and 10°C with RH of 85-90% for 2, 4 and 8 wk.

### Postharvest Treatments

One day after harvest, sweet lime fruits were washed with tap water and divided into 6 lots of 400 uniform fruits using a completely randomized design with three replications. The treatments consisted of a wetting agent only, 3000 and 6000 ppm a.i. TBZ, 3000 and 6000 ppm a.i. TBZ plus wax ("Technimul" Dussek Campbell Pty of Australia Ltd.) (1:2 v/v), 3000 and 6000 ppm a.i. benomyl, 3000 and 6000 ppm plus wax, and wax only. Each lot of fruits was dipped in appropriate solutions containing wetting agent for 2 min, drained and dried.

Treated lots were divided into random samples of 5 fruits and kept in perforated polyethylene bags and stored at 3 and 10°C with RH of 85-90%

for 2, 4 and 8 weeks. Samples of treated fruits at two-week intervals were evaluated throughout the storage period. To determine the effect of treatments on chilling injury (CI), samples were kept at 18°C for 48 hr after removal from cold storage at 3 and 10°C and damage by CI was evaluated by inspecting for external pitting. CI (pitting) was rated from 0 to 5 and CI scores were calculated by the method described by Wardowski *et al.* (10).

## RESULTS

CI (pitting) was observed on sweet lime after two wk of storage at 3 and 10°C regardless of dip treatments (Tables 1, 2 and 3). Pitting developed on fruits after 4 and 8 wk, and the rate of CI scores were enhanced by increasing the storage period.

Preharvest application of TBZ had no significant effect on reduction of chilling injury at both storage temperatures. Benomyl at 3000 and 6000 ppm significantly, reduced CI after 4 and 8 wk of storage at 3°C, and the concentration of 3000 ppm significantly reduced chilling injury of fruits at 10°C (Table 1).

Postharvest application of TBZ was more effective than benomyl in controlling CI after 4 wk and TBZ at 3000 ppm was effective until 8 wk of storage at 3°C (Table 2). Thiabendazole at both concentrations significantly reduced pitting after 8 wk of storage at 10°C (Table 2). Plain wax coating had no significant effect on reduction of pitting at both storage conditions.

Treatments of TBZ and benomyl at 3000 ppm when followed by wax coating significantly reduced chilling injury after 8 wk of storage at 10°C (Table 3).

Table 1. Effects of preharvest application of TBZ and benomyl and wax coating on incidence of surface pitting (chilling injury) of sweet lime fruits.

| Treatment | Chilling injury score† | | | | | |
|---|---|---|---|---|---|---|
| | 3°C | | | 10°C | | |
| | Weeks in storage | | | Weeks in storage | | |
| | 2 | 4 | 8 | 2 | 4 | 8 |
| Control | 0 | 13.33¶ a | 40.00 ab | 0 | 5.33 a | 14.67 ab |
| Wax coating | 0 | 13.30 a | 28.00 bc | 0 | 2.67 a | 14.67 ab |
| TBZ(3000 ppm) | 0 | 13.33 a | 45.33 a | 0 | 4.00 a | 16.00 a |
| TBZ(6000 ppm) | 0 | 12.00 a | 48.00 a | 0 | 5.00 a | 16.00 a |
| BL(3000 ppm) | 0 | 0 b | 17.33 c | 0 | 0 a | 6.67 c |
| BL(6000 ppm) | 0 | 0 b | 20.00 c | 0 | 0 a | 8.00 b |

† Chilling injury score=individual fruits scored 0 to 5, then (total points score × 100)/(No. of fruit in sample × 5).

¶ Mean separation in columns by Duncan's multiple range test at 5% level.

BL= benomyl, TBZ= thiabendazole

Table 2. Effects of postharvest application of TBZ and benomyl and wax coating on incidence of surface pitting (chilling injury) of sweet lime fruits.

| Treatment | Chilling injury score† | | | | | |
|---|---|---|---|---|---|---|
| | 3°C | | | 10°C | | |
| | Weeks in storage | | | Weeks in storage | | |
| | 2 | 4 | 8 | 2 | 4 | 8 |
| Control | 0 | 13.33¶ a | 40.00 a | 0 | 5.33 a | 14.67 a |
| Wax coating | 0 | 13.33 a | 28.00 ab | 0 | 2.67 a | 14.67 a |
| TBZ(3000 ppm) | 0 | 1.33 b | 24.00 b | 0 | 2.67 a | 4.00 c |
| TBZ(6000 ppm) | 0 | 4.00 b | 40.00 a | 0 | 1.33 a | 8.00 bc |
| BL(3000 ppm) | 0 | 2.67 b | 29.33 ab | 0 | 2.67 a | 9.33 abc |
| BL(6000 ppm) | 0 | 4.00 b | 33.33 ab | 0 | 2.67 a | 12.00 ab |

† Chilling injury score=individual fruits scored 0 to 5, then (total points score × 100)/(No. of fruit in sample × 5).

¶ Mean separation in columns by Duncan's multiple range test at 5% level.

BL= benomyl, TBZ= thiabendazole

Table 3. Effects of postharvest application of TBZ plus wax; benomyl plus wax and wax coating on incidence of surface pitting (chilling injury) of sweet lime fruits.

| Treatment | Chilling injury score† | | | | | |
|---|---|---|---|---|---|---|
| | 3°C | | | 10°C | | |
| | Weeks in storage | | | Weeks in storage | | |
| | 2 | 4 | 8 | 2 | 4 | 8 |
| Control | 0 | 13.33¶ a | 40.00 a | 0 | 5.33 a | 14.67 a |
| Wax coating | 0 | 13.33 a | 28.00 ab | 0 | 2.67 a | 14.67 a |
| TBZ(3000 ppm) + wax | 0 | 5.33 a | 25.33 b | 0 | 1.33 a | 8.00 bc |
| TBZ(6000 ppm) + wax | 0 | 5.33 a | 28.00 ab | 0 | 4.00 a | 10.67 ab |
| BL(3000 ppm) + wax | 0 | 8.00 a | 26.67 b | 0 | 1.33 a | 5.33 c |
| BL(6000 ppm) + wax | 0 | 10.67 a | 29.33 ab | 0 | 4.00 a | 5.33 c |

† Chilling injury score=individual fruits scored 0 to 5, then (total points score × 100)/(No. of fruit in sample × 5).

¶ Mean separation in columns by Duncan's multiple range test at 5% level.

BL= benomyl, TBZ= thiabendazole

## DISCUSSION

The effects of TBZ and benomyl on preventing pitting injury in sweet lime in this study were decreased by increasing the concentration (Table 1, 2 and 3). However, Schiffman-Nadel *et al.* (8) reported that the effect of TBZ on reduction of chilling injury in grapefruit was enhanced by increasing the concentration and residues in the peel. The difference between these two results may be due to the species and peel morphology. Miller *et al.* (5) reported that TBZ at very low concentration did not reduce pitting in grapefruit.

Preharvest spray of benomyl was more effective than TBZ in reduction of chilling injury. When fruits were dipped in individual solutions of TBZ and benomyl the effectiveness of TBZ in reducting of CI was greater than benomyl (Table 2). These results are in agreement with those obtained by Schiffman-Nadel *et al.* (8) who showed that TBZ was more effective than benomyl at all concentrations tested. It may be concluded that these two benzimidazoles differ in their mode of action and mobility within the tissue (8).

The results of this study and previous studies reported by others (6, 8, 11) indicated that TBZ and benomyl besides their fungicidal action also have physiological effects. Reduction of chilling injury by these two chemicals may be related to a decrease in the rate of peel senescence (8). Benzimidazoles have some growth-regulating properties which are probably due to the similarity of their structures to that of cytokinin (9). Several reports indicated that thiabendazol and benomyl like cytokinin inhibited senescence of leaves and inflorescence in different crops (6, 9, 11).

Another possibility is that benzimidazole may retard the loss of unsaturated fatty acids in peel membrane and reduce the severity of CI in sweet lime fruits at low temperature.

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