Degreening of Waxed Citrus Fruit with Ethephon and Temperature

Otto L. Jahn
Agricultural Research Service, U.S. Department of Agriculture, Orlando, FL 32803

Abstract. Postharvest application of 500 ppm (2-chloroethyl)phosphonic acid (ethephon) induced degreening in 'Bearss' lemon at 15, 18 and 21°C, reducing the coloring time by 20 to 30%. Waxing delayed degreening slightly, but, on ethylene-treated fruit, degreening was as rapid or more rapid than on untreated, unwaxed fruit. Combination of thiabendazole (TBZ) with ethylene had little effect on the degreening rate. 'Marsh' grapefruit from an interior Florida grove was more responsive to ethylene than was fruit from an east coast grove. Waxing and TBZ treatments delayed degreening more in grapefruit than in lemon. Waxing east coast grapefruit did not satisfactorily degreen with or without the addition of ethylene. Degreening occurred in waxed 'Hamlin' orange and 'Dancy' tangerine, but color was not satisfactory, mainly because of poor carotenoid development.

Materials and Methods

'Bearss' lemons (Citrus limon (L.) Burm. f.), grown on rough lemon (C. limon (L.) Burm. f.) rootstock, 'Marsh' grapefruit (C. paradisi Macf.) on sweet orange (C. sinensis (L.) Osbeck, interior Florida grove) and sour orange (C. auranium L., east coast grove) rootstocks were the main cultivars used in these studies. Limited work also was done on 'Hamlin' orange (C. sinensis (L.) Osbeck) and 'Dancy' tangerine (C. reticulata Blanco).

Each year, from 1970 to 1974, fruit were harvested during the normal degreening season for each cultivar. Samples (10 grapefruit or 20 fruit of other cultivars) were prepared and treated after harvest. The specific treatments varied between tests but included temp of 15, 18, 21, 27°C (60, 65, 70, 80°F); ethylene at 0, normal and half strength, TBZ fungicide at 0, 1,000 ppm, and ethylene at 0, 10 ppm. This ethylene level is above the initial chlorophyll level is low (8).

Waxing also reduces the degreening rate in ethylene-treated lemons (3), oranges and grapefruit (4). Other work showed that application of ethylene immediately after harvest could initiate degreening of lemons during transport from the grove to the packinghouse (6). In the present work, methods were evaluated for the induction of degreening of waxed citrus fruits.

Citrus fruits that need degreening are normally exposed to ethylene after harvest and before packing. For domestic markets, this procedure is necessary to minimize the time required for color development. For export markets, sufficient time should be available for degreening in transit. Untreated citrus fruit may be degreened in 2 to 3 weeks at temp of 60 to 70°F (15 to 21°C) (2, 5, 6, 8, 9). Waxing is necessary to minimize moisture losses during marketing, but it also retards degreening in both untreated (2, 8, 10) and ethylene-treated fruit (3, 4). This may prevent satisfactory color development unless the initial chlorophyll level is low (8).

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Results and Discussion

'Bearss' lemon. Better degreening and less decay were observed at 15 to 21°C than at 27°C in initial studies on 'Bearss' lemons. Therefore, the higher temp was dropped in later studies. Untreated lemons degreened satisfactorily at 15°C (Fig. 1). (This is the present method of degreening Florida lemons.) Degreening was significantly more rapid at 15°C than 21°C in untreated fruit but, with 500 ppm ethylene, there was more rapid degreening at 21°C (Fig. 1) than at 15°C. This interaction between temp and ethylene concn was highly significant after 7 days from harvest. In this test, 300 ppm was less effective and 700 ppm about equal (data not shown) to 500 ppm

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Fig. 1. Chlorophyll (AOD) changes in 'Bearss' lemon treated with 0 or 500 ppm ethylene and held at 15, 18 or 21°C. Ethylene applied to unwashed (UW), washed and waxed (W,W), or washed, TBZ fungicide-treated and waxed (W,F,W) fruit. Harvested Sept. 9, 1974. Statistical significance (1%) shown for T = temp, E = ethylene concn, W = washing, waxing and fungicide treatments, and TXE, TXW, WXE interactions.
ethephon in degreening response. In other tests, 500 ppm was as effective as 1,000 to 2,000 ppm.

Washing and waxing the lemons had small but significant effects on the degreening rate. The slightly accelerated degreening in waxed, ethephon-treated fruit at 15 and 18°C (Fig. 1) may be due to the retention of higher ethylene levels in the fruit by the wax. The expected slower degreening in waxed fruit was evident in waxed control fruit at 21°C but not where ethephon was applied (Fig. 1). TBZ followed by waxing did not affect the degreening rate at 15 or 18°C. There was some delay in fruit treated with TBZ and ethephon at 21°C. Slight delays in degreening because of waxing or TBZ applications were also observed in other lemon tests. With these small effects of treatments, the in-transit degreening of waxed lemons with ethephon at 15°C appears to be possible.

Orange and tangerine. Studies with ethephon and wax on ‘Hamlin’ orange during the 1970 and 1971 seasons showed limited improvement in fruit color (data not shown). More extensive color responses occurred on ‘Dancy’ tangerine during 2 tests in 1970. In both cultivars, carotenoid development was minimal in waxed fruit, as was observed with unwaxed ethephon treatments (5). Work with these cultivars was discontinued because of this problem and the greater benefit of in-transit degreening methods for grapefruit.

‘Marsh’ grapefruit. Ethephon and ethylene accelerated degreening in ‘Marsh’ grapefruit (interior Florida grove) held at 21°C (Fig. 2). Waxing reduced the effectiveness of both chemicals and also delayed degreening in the waxed control fruit. Similar responses were observed at 27°C. These results support the generally observed reduction in degreening rate in waxed fruit (2, 8, 10). Although the reductions shown are greater than occurred with waxed lemons, degreening in waxed, ethephon-treated grapefruit was comparable to that of the untreated control. Maintenance of this rate would be needed for an acceptable in-transit degreening procedure.

In additional studies, reducing the wax content in the solvent by half did not improve the degreening rate of grapefruit. One possible effect of TBZ on ethephon degreening was thought to be through pH changes. The pH of 700 ppm ethephon was increased from about 2.6 to 3.2 by the addition of 1,000 ppm TBZ. Lowering the pH to compensate for the TBZ did not appear to improve degreening. The basic formulation of TBZ used in most studies raised the pH of the mixture to about 5.0. This formulation was not available when the pH study was made.

The east coast fruit degreened more slowly (Fig. 3) than the interior grapefruit (Fig. 2) at 21°C. Other studies generally showed greater degreening responses in waxed fruit from interior than from east coast groves. In other work, untreated interior grapefruit degreened more rapidly than comparable east coast fruit but no difference in response to ethylene was observed (7). These differences in degreening response in grapefruit (and lemons) may be expected from the many differences in rootstock, soil type, water supply, fruit maturity, etc., which directly or indirectly affect the enzyme activity in the fruit. No measurements were made of the metabolic activity in these fruits. The east coast grapefruit generally matures earlier than interior fruit while lemons tend to be picked at a less-mature
stage. This suggests that the east coast grapefruit may have a lower metabolic rate with less potential for enzyme synthesis in response to treatment. The continued changes observed in grapefruit that was waxed after degreening was initiated (4) may provide an alternative approach to in-transit degreening.

**Literature Cited**


**Influence of a Substituted Oxathiin, a Localized Growth Inhibitor, on the Stem Elongation, Branching, and Flowering of Chrysanthemum morifolium Ramat**

Henry M. Cathey

Agricultural Research Service U.S. Department of Agriculture, Beltsville, MD 20705

**Abstract.** 2,3-dihydro-5,6-diphenyl-1,4-oxathiin, chemical disbudding, flowering, pinching?

Regulation of the growth and form of plants is exerted through physical, environmental, and chemical means. The physiological state of plants determines the effectiveness and relative consistency of chemical or manual pruning techniques from one test to the next. Without this understanding, most treatments with chemicals will fail to gain acceptance due to their unpredictable results on plants (2, 20, 21). Chemical growth retardants such as succinic acid-2,2-dimethyl hydrazide (SADH, daminozide) and ancymidol (23) can be used to control growth of tissues at distances from treated areas (3, 8, 9, 19, 24, 28). Systemic growth inhibitors either kill or stop the growth of tissues (1, 4, 18, 28). The test emulsions of the chemicals were applied to vegetative chrysanthemum plants. UBI-P293 blocked development of the top 8—10 nodes; whereas lateral shoots developed at the same rate, number, and weight as those observed on manually pruned plants. When applied to plants initiating flowers, UBI-P293 caused chemical disbudding by blocking development of laterals while the terminal bud was exempt and expanded into a normal inflorescence. The optimum concentration for the 35 cultivars evaluated varied from 0.25 to 1.0% when applied between 15 to 24 short days. Higher concentrations or earlier applications of UBI-P293 inhibited all development.

**Materials and Methods**

**Test plants.** The test emulsions of the chemicals were applied to *Chrysanthemum morifolium* cvs. #4 Improved Indianapolis White, Bright Golden Princess Anne, Superchief, Streamer, Goldburst Mefo, Fred Shoesmith, and Iceberg. The plants were grown from rooted cuttings in a pad and fan-cooled greenhouse, in photoperiodic conditions that assured their remaining in a vegetative condition throughout the experiments. These conditions consisted of natural photoperiods and 4 hr of light from incandescent lamps of 200 lux from 2200 to 0200 daily. To induce flowering, the plants were covered with black sateen cloth nightly from 1600 to 0800 to give the plants an 8 hr day.

**Spray emulsions.** UBI-P293 4 concn (47.3% a.i. emulsifiable concentrate) ranged from 0.125 to 1.0%. A blank emulsion, containing only the solvents and surfactants, was applied to plants to determine the toxicity of the carriers of the UBI-P293. The emulsions were used as soon as prepared.

**Test method.** The emulsions were applied with an ordinary atomizer. The entire top of the plant, including terminal meristem and surrounding leaves of various stages of maturity, was sprayed until the emulsion began to glisten on the foliage; 750 ml of emulsion were required to treat 100 chrysanthemum plants, 30 cm tall. A mechanical fogger with either a 0.33 or 2.29 mm orifice was also used to apply the emulsions to test plants. Thirty and 120 ml, respectively, were required to treat the test emulsions of the chemicals to areas of 30 and 100 m², respectively.