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NOTE

INHIBITION OF C_2H_4 AND CO_2 PRODUCTION OF HARVESTED TOMATO FRUITS BY MENADIONE[1]

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Abstract – Harvested mature green tomatoes (*Lycopersicon esculentum* Mill.) were dipped in oil soluble and water soluble forms of Menadione. Dipping for 10 min in 0.1% w/v emulsion or dispersion of Menadione and 0.3% or 0.4% w/v solution of Menadione sodium bisulfite delayed fruit ripening up to 5 weeks at 20°C. Some variability was noted between and within treatments. Water soluble Menadione was found to be capable of both enhancing and retarding ripening, depending upon the concentration used. Rates of C_2H_4 and CO_2 evolution by fruits receiving concentrations of Menadione sodium bisulfite that retarded ripening were considerably lower than controls.

INTRODUCTION

Tomatoes (*Lycopersicon esculentum* Mill.) are frequently shipped to distant markets for which they are picked mature green and allowed to ripen in transit or retail stores. Some fruits turn red in 1 or 2 days and some after a week or 10 days at room temperature. It has been reported that mature green tomatoes turn 100% red at 20°C within 13 days after harvest [8].

At low temperatures, the ripening of fruit is generally slower and more gradual. Ripening of mature green tomatoes is reported to be slower at 16°C than at 20°C [7] and also slower at 12.8°C than at 15°C and 20°C [8].

Refrigeration is costly or not available in many parts of the world. Thus, other means of retarding fruit ripening, including chemicals without need for refrigeration should be investigated.

Post-harvest application of growth regulators, particularly gibberellic acid, is reported to delay ripening of mature green tomatoes for several days [1, 2, 5]. Post-harvest dipping of mature green bananas in 0.1% emulsion of vitamin K_1 and 0.1% solution of vitamin K_3 for 5 min delayed ripening of the fruits for 33 and 24 days, respectively [3].

It was our attempt in this laboratory to investigate the possibilities of post-harvest

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application of vitamin-K compounds on various commodities. The effect of Menadione on retarding ripening of mature green tomatoes was studied and is reported here.

MATERIALS AND METHODS

Commercial, hydroponically-grown greenhouse tomatoes (cv. Tropic) were used. The fruits were harvested at the mature green stage on 17 May, 1974, were selected for uniformity of size and color and were treated on the same day.

The treatments were: (1) distilled water control; (2) 0.4% Tween 20 (polyoxyethylene sorbitan monolaurate), a surfactant; (3) 0.8% DMF (*N, N'*-dimethyl-formamide), an organic solvent; (4) 0.4% Tween 20 + 0.8% DMF + 0.1% Menadione (2-methyl-1, 4-naphthoquinone); (5) 0.1% Menadione dispersion (water sonicated for 30 min); (6) 0.2% Menadione sodium bisulfite (2-methyl-1, 4-naphthoquinone sodium bisulfite); (7) 0.3% Menadione sodium bisulfite; and (8) 0.4% Menadione sodium bisulfite.

Eight fruits were used in each treatment. Dipping period for all treatments was 10 min after which the fruits were allowed a few minutes to drain off excess solution and dry before placing in lidded fiberboard boxes and transferring to a 14.4°C storage room. Relative humidity of the air in the storage room was about 65%.

The fruits were inspected daily for general appearances such as turning, softening and sepal condition for a period of 15 days, until 3 June, 1974. During this period, turning fruits were removed.

On the 16th day after treatment, a weighed amount (750–800 g) of remaining green fruits were taken from each treatment and placed in sealed 4-l respiration chambers at 20°C. A known volume of air (2.00–2.25 l/hr) was passed through the chambers. The air leaving the chambers was analysed daily for C_2H_4 and CO_2 for the next 17 days, which corresponded with 17–33 days after treatment. At the end of the first week (23 days after treatment), turning fruits were taken out. The remaining green fruits were cleaned of some fungal growth by removing the sepals, weighed, replaced in containers and sealed.

Ethylene was measured with a Model 700 Hewlett-Packard flame ionization gas chromatograph. Carbon dioxide was measured with a Model No. 29 Fisher-Hamilton gas partitioner.

The rate of ethylene evolution was calculated as μl C_2H_4/kg per hr. The rate of respiration was calculated as ml CO_2/kg per hr.

According to the specifications, 1 mg of Menadione is about equivalent to 2 mg of Menadione sodium bisulfite [6]. It is our impression that Menadione sodium bisulfite, at 0.3% concentration may display a somewhat similar physiological effect, specifically on retarding ripening of mature green tomatoes, to that of 0.1% Menadione.

RESULTS AND DISCUSSION

The rates of C_2H_4 and CO_2 evolution by the fruits in various treatments, determined from 17–33 days after treatment, are shown in Figs. 1 and 2, respectively. Control fruits were consistently highest in rates of C_2H_4 evolution. During the first 7 days (17–23 days

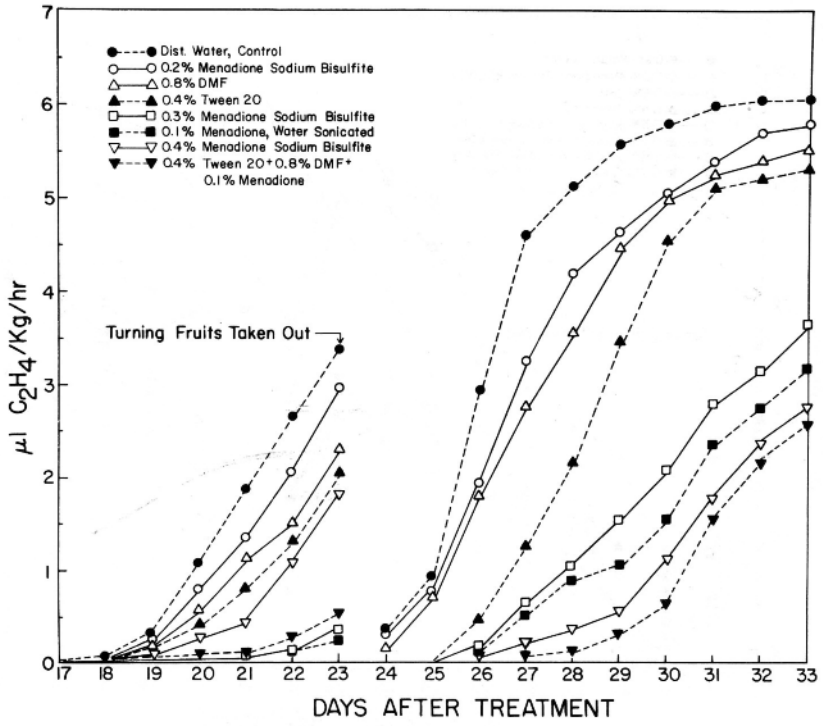

Fig. 1. The effect of Tween 20, DMF, Tween 20 + DMF + Menadione, water dispersion of Menadione and 3 levels of Menadione sodium bisulfite on ethylene production by ripening tomato fruits in comparison to control.

after treatment), the fruits dipped in 0.1% Menadione dispersion and 0.3% Menadione sodium bisulfite solution had the lowest rates of C_2H_4 evolution. A minor difference was noted between the two treatments. However, during the next 10 days (24–33 days after treatment, upon excluding turning fruits), the rate of C_2H_4 evolution was lowest in fruits dipped in 0.1% Menadione emulsion prepared by using 0.8% DMF plus 0.4% Tween 20.

Generally, fruits dipped in 0.1% Menadione dispersion (water sonicated), 0.1% Menadione emulsion and 0.3% Menadione sodium bisulfite produced C_2H_4 and CO_2 in lower rates than the fruits of other treatments. In some cases, however, fruits dipped in 0.4% Menadione sodium bisulfite solution displayed lower rates of C_2H_4 and CO_2 evolution than the fruits treated with 0.3% solution. It was noted that 0.2% Menadione sodium bisulfite solution often enhanced turning and softening of fruits.

As shown in Figs. 1 and 2, both 0.8% DMF and 0.4% Tween 20 had at least some suppressing effect on C_2H_4 and CO_2 evolution. Ethylene evolution by fruits dipped in distilled water, 0.8% DMF, 0.4% Tween 20 and 0.2% Menadione sodium bisulfite occurred at relatively higher rates than the fruits of other treatments. The production rates reached maximum at about 30 days after treatment and leveled off thereafter. Most fruits were table ripe at this time. However, C_2H_4 evolution by fruits dipped in 0.1%

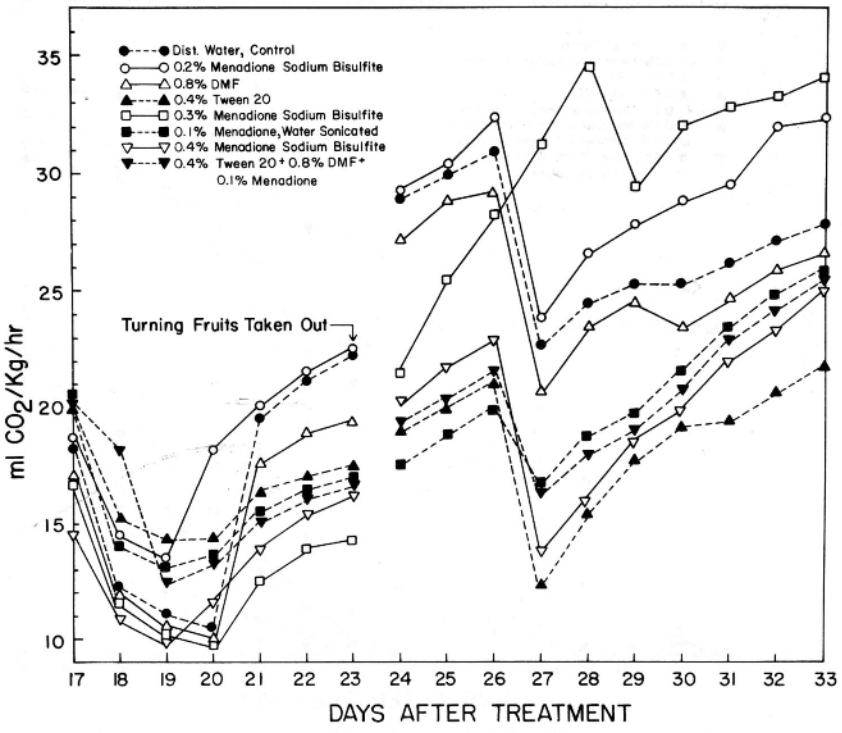

Fig. 2. The effect of Tween 20, DMF, Tween 20 + DMF + Menadione, water dispersion of Menadione and 3 levels of Menadione sodium bisulfite on respiration of ripening tomato fruits in comparison to control.

Menadione dispersion or emulsion and 0.3% and 0.4% Menadione sodium bisulfite was still rising abruptly even at 33 days after treatment and did not reach the plateau. These fruits were mostly green or at breaker stage. When stored at 20°C, the fruits still remained relatively green and firm up to 5 weeks following the treatments.

The treatment effects on respiration of the fruits, particularly the climacteric rise, were not consistent and variations were noted. During the first 7 days after treatments, fruits dipped in 0.3% Menadione sodium bisulfite were lowest and those dipped in 0.2% of the same compound were the highest in CO_2 evolution. From 24–33 days after treatment, however, 0.4% Tween 20-treated fruits had the highest levels of CO_2. An overall judgment on respiration data is that 0.1% Menadione dispersion or emulsion, 0.3% or 0.4% Menadione sodium bisulfite and 0.4% Tween 20 displayed lower rates of CO_2 evolution as compared to other treatments.

Mature green tomatoes dipped in 0.1% w/v emulsion or dispersion of Menadione and 0.3% or 0.4% w/v solution of Menadione sodium bisulfite delayed ripening up to 5 weeks. Treated fruits were generally greener and firmer than controls at any particular time following treatment, although no color and firmness data were obtained. Their rates of

C_2H_4 evolution and respiration were considerably lower than those of control (Figs. 1 and 2).

Providing no definite and specific explanation for the experimental findings at this stage, it seems that Menadione displays an inhibitory role in ethylene pathway. As our data represent (Fig. 1), the rate of C_2H_4 evolution by Menadione-treated fruits was generally much lower than that of control. In accordance with the current belief that the onset of climacteric rise in respiration occurs when the burst of C_2H_4 evolution by the ripening fruit takes place [4], a similar coincidence was noted (Figs. 1 and 2). When turning fruits were taken out from the respiration chambers after a week (at 23 days after treatment), the remaining green fruits produced C_2H_4 at very low rates. In fact, the rate of C_2H_4 evolution by fruits treated with 0.1% Menadione emulsion or dispersion and also with 0.3% or 0.4% Menadione sodium bisulfite solution dropped to zero and remained as such for a period of 2 days. The rate of CO_2 evolution, however, continued to rise for about 2 days and decreased abruptly thereafter. Continued rise in respiration rate after the removal of turning fruits seemed to be a residual response of fruits to exogenous C_2H_4 evolved by the turning fruits. However, the new rise in CO_2 evolution afterwards was due to endogenous C_2H_4 production. The climacteric rise of respiration in remaining green fruits again coincided with the sharp rise in C_2H_4 evolution by the ripening fruits.

Menadione may also defer the respiration of ripening fruits. Although variations were noted, the rate of CO_2 evolution by Menadione treated fruits was generally lower than that of control (Fig. 2). Evidently, the inhibitory effect of the compound on respiration was not consistent.

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