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Hung, Duong Van
Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University

Morris, Stephen
Faculty of Agriculture Food and Natural Resources, The University of Sydney

Mcconchie, Robyn
Sydney Postharvest Laboratory

Tanaka, Fumihiko
Laboratory of Postharvest Science, Faculty of Agriculture, Kyushu University

他

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Rockmelon (*Cucumis melo* L.) Fruit Ripening and Postharvest Quality Following Application of Aminoethoxyvinylglycine

Duong Van HUNG[1]*, Stephen MORRIS[2], Robyn MCCONCHIE[3], Fumihiko TANAKA[4], Daisuke HAMANAKA[4] and Toshitaka UCHINO[4]

Laboratory of Postharvest Science, Department of Bioproduction Environmental Sciences,
Faculty of Agriculture, Kyushu University,
Fukuoka 812–8581, Japan
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ReTain (Valent BioScience Corporation, Sydney) plant growth regulator is a commercial formulation of aminoethoxyvinylglycine (AVG). This compound is known to competitively inhibit the activity of the enzyme ACC (1–aminocyclopropanecarboxylate) synthase which is the rate–limiting enzyme in the metabolic cycle of ethylene production. Ethylene is a naturally occurring plant hormone that stimulates ripening in climacteric melon fruit, such as rind colour change, flesh softening and production of volatiles. Pre–harvest application of ReTain at the concentration of 125 ppm on rockmelon plants 2 weeks before harvest inhibited postharvest ethylene production. Melons harvested from plots treated with ReTain had lower rates of ethylene production at harvest and after cold storage than melons harvested from control plots. The ethylene inhibition resulted in a delay of fruit ripening of about 2 days. ReTain–treated fruit had a firmer flesh than untreated fruits. In addition, delayed fruit maturity showed less incidence of disease. The results suggest that application of ReTain has major benefits as a harvest management tool for rockmelon production, allowing growers to regulate fruit ripening, improve fruit quality and reduce postharvest rot severity.

Keywords: Ethylene production; AVG; Fruit ripening; Rot severity

INTRODUCTION

Rockmelon or cantaloupe (*Cucumis melo* L.var. *reticulatus*) is a climacteric fruit exhibiting rapid changes in morphology and physiology during the maturation stages (Lelievre *et al.*, 2000). Ripening of the fruit involves a wide range of complex reactions generating changes in enzyme, respiratory activity, ethylene production and sugar content. Ripening and fruit quality in melons is predominantly evaluated by the sugar content. The soluble solids content in a ripe melon varies between cultivars, ranging from 8 to 17% Brix (Bianco and Pratt, 1977; Miccolis and Saltveit, 1991). The onset of fruit ripening coincides with a climacteric rise in endogenous ethylene production. Therefore, the control of ethylene production should make it possible to develop strategies to regulate ripening of melons on the vine and to slow down postharvest senescence. Ethylene biosynthesis in rockmelon follows the pathway from methionine to ethylene via S–adenosylmethionine (SAM) and 1–aminocyclopropane–1–carboxylic acid (ACC) (Liu *et al.*, 1985). ReTain is a commercial product containing the plant growth regulator aminoethoxyvinylglycine (AVG). This compound is reported to suppress ethylene biosynthesis by inhibiting the activity of the enzyme ACC synthase, responsible for the conversion of SAM to ACC (Yang and Hoffman, 1984). It is noted that the conversion of SAM to ACC, rather than conversion of ACC to ethylene, is sensitive to AVG inhibition. Response to this inhibitor requires its application prior to the onset of rapid ACC synthesis (Yang, 1985). Therefore, a chemical that can retard the formation of ethylene could have an important postharvest benefit in extending the shelf life of fresh rockmelon.

Pre and postharvest applications of AVG have been evaluated for enhancement of production and quality attributes of other fruits. The application of AVG to ‘Tegan Blue’ plum trees 10 days before commercial harvest was shown to maintain the firmness for late–harvest fruit and to suppress the production of endogenous ethylene after 4 weeks in storage (Jobling *et al.*, 2003). Application of 200 ppm AVG to Satsuma mandarins at the beginning of blooming reduced ethylene production from flowers and young fruit and improved fruit set at 30 °C (Ogata *et al.*, 2002). Clayton (2000) reported that AVG suppressed ethylene production, softening, and loss of chlorophyll in ripening pears and mature green pears cold–stored for 4 months. When AVG was applied as both preharvest spray and a postharvest dip treatment on peaches and nectarines, it reduced fruit softening and ethylene emission (Byers, 1997b; Bregoli *et al.*, 2002). Postharvest treatment with AVG has also been trialed on apricots and has been shown to delay fruit softening and reduce ethylene production (Palou and Crisosto, 2003). Results from these trials suggest that the practical advan-

[1] Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University, 6–10–1, Hakozaki, Higashi–ku, Fukuoka, 812–8581, Japan
[2] Faculty of Agriculture Food and Natural Resources, John Woolley Blg. A20, University of Sydney NSW 2006, Australia
[3] Sydney Postharvest Laboratory, PO Box 62, North Ryde, NSW 2113, Australia
[4] Laboratory of Postharvest Science, Faculty of Agriculture, Kyushu University, 6–10–1, Hakozaki, Higashi–ku, Fukuoka, 812–8581, Japan
* Corresponding author (E–mail: hungvanduong@gmail.com)

tages of pre and postharvest AVG application are species and even cultivar specific. The objective of this trial is to identify whether preharvest applications of AVG (ReTain) could delay fruit ripening and improve postharvest quality attributes of melons.

MATERIALS AND METHODS

Source of fruit

Rockmelons were grown at 'Amaland' farm, in Griffith, NSW Australia. Rockmelon seeds, cv. 'Frontier', were sown and grown under standard commercial practice, consisting of a single row of plants at 50 cm spacing between plants, on a 1.2 m wide bed. The beds were covered with black plastic mulch, with drip tape underneath. ReTain (aqueous solution 5% a.i, Valent BioScience Corporation, Sydney) was sprayed until run–off at concentration of 125 ppm with 0.01% of Tween 80 as surfactant. Control plots were sprayed with water and Tween 80. The treatment was applied once only at 2 weeks before anticipated harvesting time in the early morning using pressure sprayer of 6 litre. Time of harvest was determined based on between 40 and 45 days after fruit set depending upon cultivar and crop season. The experimental design was a randomized design with each treatment being replicated three times, the size of a replicated plot was 48 m^2 (40 m length and 1.2 m width) with each plot consisting 80 plants.

Harvesting

Prior to harvest date, all melons from each plot were marked by a numbered yellow adhesive dot. Trial melons were picked daily over a period of 14 days by experienced harvesters along with commercial melons, and then transported to the packing shed where marked fruits were isolated. Fruit were classified into two categories green full–slip (peduncle tissue completely detached from the abscission zone but green skin) and yellow full–slip. A total of 84 ReTain–treated fruit and 79 untreated fruit were harvested by the end of the season. Forty green full–slip melons (20 ReTain–treated fruit and 20 control fruit) were transported by airplane to the Sydney Postharvest Laboratory (North Ryde, Sydney) for postharvest assessments. These fruits were then stored at 2 °C for 2 weeks, and then removed from cold storage and placed to 20 °C for a week to evaluate disease incidence. The fruit were left for 3 h to warm up to room temperature before evaluating flesh firmness and decay incidence. Since oversea shipping by sea usually takes two weeks and a week for marketing, therefore, the experiment was designed similarly to sea transport.

Fruit quality assessment

Flesh firmness was measured by removing a thin piece of rind and pressing onto the flesh using a penetrometer (Effegi, Italy) with an 11 mm (7/16–inch) tip mounted in a drill press. Three measurements were taken at equidistant points around the equator of the fruit. The fruit were then dissected longitudinally and assessed for color measurement and soluble solid content (SSC). The percentage of soluble solid content (% Brix) was measured using a hand–held refractometer (Atago, Japan) with juice from each half of the middle section of flesh. The ethylene production rate ($\mu L \cdot kg^{-1} \cdot h^{-1}$) of melons was measured by placing each fruit in a 5,250 mL plastic container hermetically sealed with a rubber stopper. After 1 h, 0.5 ml of the container headspace gas was withdrawn with a gas syringe and the ethylene was quantified using a gas chromatograph coupled to flame ionization detector (Shimadzu GC–17A, Japan and GS–Q column J &W Scientific, Germany) with helium as the carrier gas at the flow of 50 $ml \cdot min^{-1}$.

Disease Severity

Estimates of disease severity on the fruit was based on the number and diameter of lesions according to a 5–point scale following the method described by Huang *et al*. (2000).

1 = No disease
2 = One lesion less than 1 cm in diameter
3 = One lesion between a diameter of 1–3 cm, or two lesions each with a diameter less than 2 cm
4 = One lesion larger than 3 cm but smaller than 3 cm, or two lesions each larger than 2 cm but smaller than 3 cm
5 = One lesion larger than 5 cm or more than 3 lesions.

Statistical analysis

Experimental data are represented by the mean ± SE of the determination for each sample. An analysis of variance was performed using GenStat (VSN International Ltd., UK) to determine treatment differences and whether differences between means of attributes were significant at the level of $P \leq 0.05$. Postharvest disease data were analyzed using Ordinal Logistic Regression in Genstat.

RESULTS AND DISCUSSION

Maturity characteristics of the melons

The effect of ReTain on the delay ripening of rockmelon is shown in Fig. 1. It can be seen that fruits were harvested over a 14–day period and showed that control fruit ripened earlier than ReTain–treated fruit. Seventy percent of melon fruit from the control plots were harvested during the first six days and with the largest number (21 fruits) harvested on the sixth day. In contrast, fifty percent of ReTain–treated melons were picked from the sixth day to the end of the season. Treating melon plants with ReTain two weeks before anticipated harvesting time delayed the harvest median day by 2.2 days (difference in days to 50% melons harvested). The delay in ripening of melons was attributed to the inhibition of ethylene production by application of ReTain.

Melon Weight and Soluble Solids Content

The mean weight of the green full–slip melons was not significantly different between treatments (P>0.05). However, the weight of yellow full–slip melons between ReTain–treated fruit and control was significantly differ-

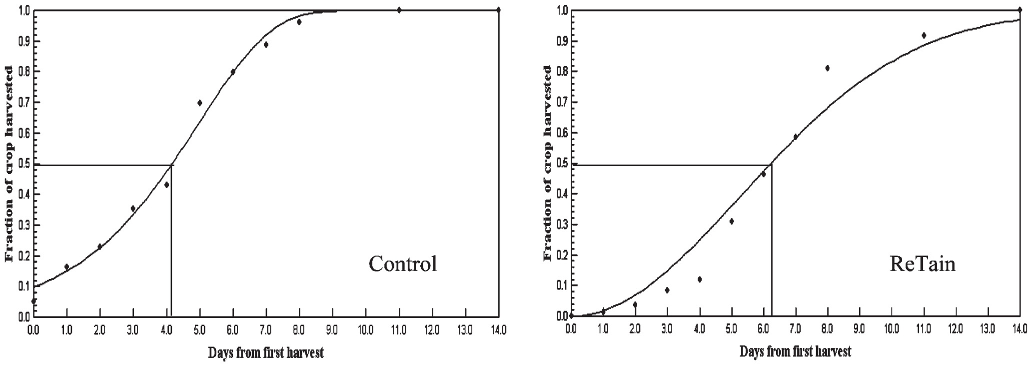

Fig. 1. The number of fruit harvested from control and ReTain (5% ai) treated plants applied 14 days pre–harvest.

ent (Fig. 2). The average weight of yellow full–slip fruit harvested from the ReTain treatment was 2,185 g which is 14% higher than that of control fruit. The increased melon weight may be attributed to delayed ripening and longer developing period on the vine. Since melons treated with AVG remained on the vine longer, the fruit would have been able to accumulate water from the continued leaf photosynthetic activity. In 'Feicheng' peaches, AVG treatment did not affect fruit weight, but soluble solids content (SSC) was significantly increased when harvest was delayed by the treatment (Ju *et al.*, 1999). The different effect of AVG on fruit weight may be explained that accumulation of water and sugar in melon fruit occurs at the harvest time faster than those in peach fruit. Soluble solids content of ReTain–treated and control fruit was not significantly different (Fig. 3).

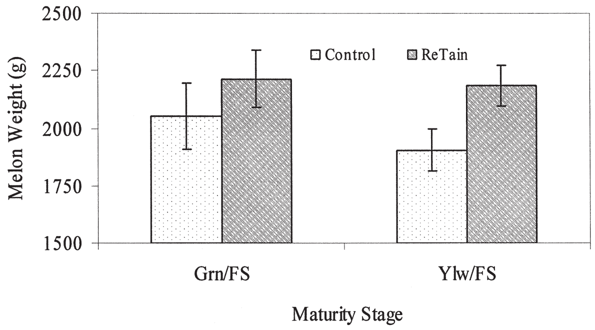

Fig. 2. Mean melon weight of fruit (± SE) harvested from control and ReTain (5% ai) treated plants applied 14 days pre–harvest, Grn/FS; green full–slip, Ylw/FS; yellow full–slip.

Firmness

There was a significant difference in flesh firmness between treatments ($P<0.05$). Fig. 4 shows that the overall firmness of ReTain–treated fruit at both harvest and post–storage times was greater than that of control fruit. Furthermore, half–slip fruit measurements were significantly firmer than for full–slip fruit. There was a substantial decrease in firmness across treatments throughout storage duration; however, the ReTain–treated fruit remained firmer at the completion of the storage period at 20 °C. The difference in firmness between ReTain–treated and control fruit at harvest was 12.4 N but this declined to 8.6 N at three week after harvest. The enhanced firmness of ReTain–treated fruit was due to the reduction of ethylene production, resulting in the delay in fruit ripening. This delay could enable fruit to have additional time for transport and marketing and may also reduce physical damage to the fruit. In previous studies, application of AVG between 2–4 weeks before harvest has been shown to delay softening in several climacteric fruit such as apples (Bramlage and Autio, 1982; Bramlage *et al.*, 1980; Greene, 2000; Wang and Dilley, 2001; Williams, 1980), peaches (Bregoli *et al.*, 2002), plums (Jobling *et al.*, 2003).

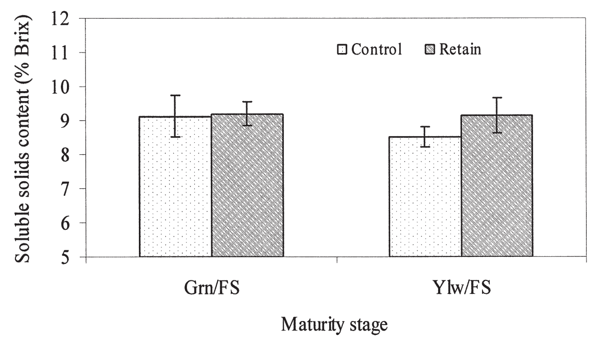

Fig. 3. Soluble solids content (SSC) in fruit harvested from control and ReTain (5% ai) treated plants applied 14 days pre–harvest, Grn/FS; green full–slip, Ylw/FS; yellow full–slip.

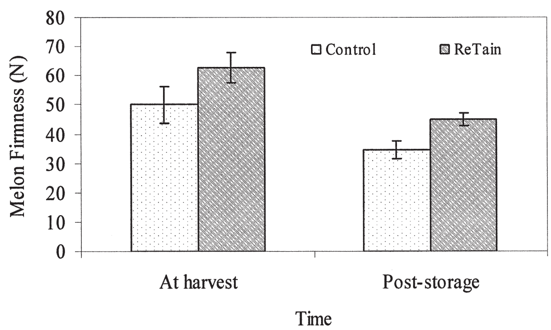

Fig. 4. Mean firmness (± SE) of ReTain (5% a.i)– treated and control melon fruit at harvest time and post–storage.

Ethylene Production

Fruit harvested from the plants sprayed with ReTain had significantly lower rates of ethylene production at harvest and post–harvest period compared to fruit from the control (Fig. 5). The ethylene amount that ReTain–treated fruit produced at harvest was about 6 times lower than that in control fruit. There was a dramatic increase in ethylene production after 3 weeks storage for both ReTain–treated and control fruits. This increased rate of ethylene in the control fruit was four times higher than that of treated fruit. In ReTain–treated fruit, ethylene produced at post–storage was 21.18 $\mu L \cdot kg^{-1} \cdot h^{-1}$ compared to 96.78 $\mu L \cdot kg^{-1} \cdot h^{-1}$ in control melons. The outcome of the experiments implies that ReTain treatment inhibited the process of melon ethylene production, leading to delayed fruit ripening and influence on other fruit parameters. The ethylene reduction in ReTain–treated fruit was similar to that reported previously for apples (Bramlage and Autio, 1982; Bramlage *et al.*, 1980; Greene, 2000; Soto *et al.*, 2001; Wang and Dilley, 2001), pears (Romani *et al.*, 1983), muskmelon (Shellie, 1999), peaches (Bregoli *et al.*, 2002), and plums (Jobling *et al.*, 2003).

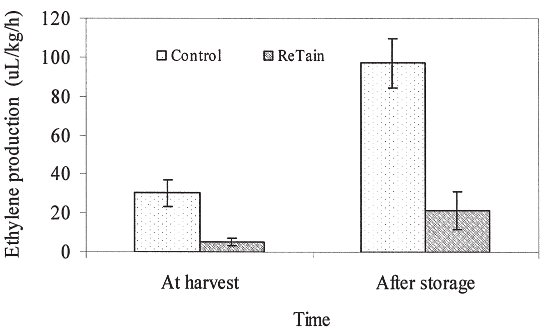

Fig. 5. Mean rate (± SE) of ethylene production of melon fruit harvested from control and ReTain (5% a.i)– treated at harvest time and post–storage.

Rot Severity

Fig. 6 presents decay incidence of melons when exposed to ambient environment at 20 °C It is apparent that there was no difference in rot severity during the first two days at 20 °C, but there was an increase in disease incidence with increased days exposed to 20 °C. From the fifth to seventh days the rot severity between the two treatments was significantly different (P<0.05) with control fruit having more disease than ReTain–treated fruit. The probability of melons having rots of score 3 on the fifth day was 8% and 45% for full–slip ReTain–treated and control fruit, respectively. When melons were exposed to 20 °C for 1 week, most melons including the ReTain–treated fruit were infected by pathogens, but the disease severity was very different between the two treatments. Overall rot severity of control fruit occurred more severely than ReTain–treated fruit at last measurement. The probability of melons getting infected at scale 5 was 73% and 5% for control and ReTain–treated melons, respectively. Reduced rot severity in ReTain fruit may be due to the delayed softening of fruit firmness which prevents melons from pathogen attacks.

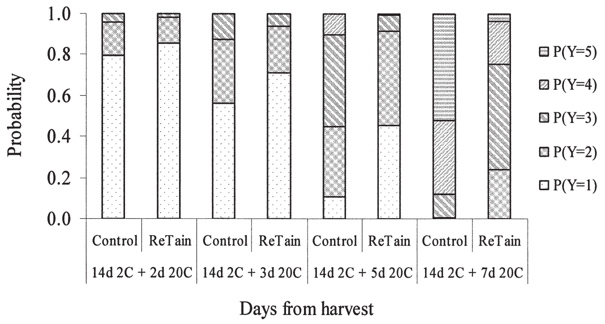

Fig. 6. Disease incidence of fruit harvested from control and ReTain (5% a.i) treated plants applied 2 weeks pre-harvest assessed at ambient environment (14d 2C + 2d 20C means 14 days at 2 °C and 2 days at 20 °C).

CONCLUSION

The pre–harvest foliar application of ReTain 2 weeks before anticipated harvesting time, delayed the median harvest day by about 2 days (difference in days to 50% melons harvested). Thus, treatment of ReTain to rockmelon plants could be of economic benefits to growers by regulating the harvest season, significantly increasing weight, reducing loss of fruit firmness, and decreasing disease incidence and loss. However, these are preliminary outcomes conducted in a small scale and further experiments in larger growing areas, over a range of seasons and locations are needed to confirm these results.

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