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Shelf Life of Custard Apple Treated with 1-Methylciclopropene - an Antagonist to the Ethylene Action

Guilherme Benassi[1], Guilherme Augusto Simões Francischini Correa[1], Ricardo Alfredo Kluge[2,3*] and Angelo Pedro Jacomino[1,3]

[1] Depto. de Produção Vegetal; USP; ESALQ. [2] Depto. de Ciências Biológicas; USP; ESALQ; C. P. 9; 13418-900; Piracicaba - SP - Brazil. [3] Bolsista CNPq

ABSTRACT

*Custard apple (*Annona squamosa *L.) presents very short storage life at room temperature, in part due to heavy losses in firmness. This process is associated with the production and action of the hormone ethylene. In order to retard the ripening evolution in custard apple, fruits were treated with the competitive ethylene antagonist 1-methycyclopropene (1-MCP) at concentrations of 0, 30, 90, 270 or 810 nL L^{-1} for 12 h at 25°C and then stored at 25°C for four days. The soluble solids content (SSC), firmness and percentage of ripe fruits (firmness $\leq$ 0.5kg) were determined during the experimental period. There were no differences among treatments as to the SSC. Fruits treated with 810 nL L^{-1} of 1-MCP showed higher firmness than the control fruits. Both , non-treated or treated fruits with 30 or 90 nL L^{-1} ripened faster than fruits treated with 1-MCP at higher concentrations.*

Key words: Ripening, storage, firmness, *Annona squamosa*

INTRODUCTION

Custard apple (*Annona squamosa* L.) is a tropical fruit which shows very short storage life at room temperature due to its fast ripening. It presents climacteric behavior, high respiration rate and ethylene production (Pal and Kumar, 1995; Prasanna et al., 2000). The fast fruit softening (firmness loss) is the main characteristic reducing the fruit's quality and commercialization.

Ethylene (C_2H_4) is well documented as being the ripening hormone of climacteric fruits. At a certain maturation stage, ethylene is linked to its binding-site in the cell and promotes several alterations which culminate in the ripening and senescence of fruits (Burg and Burg, 1967; Lelièvre et al., 1997a).

Such ethylene actions can be blocked by some compounds, such as 2.5-norbornadiene (NDB) and diazocyclopentadiene (DACP), which, when linked to the ethylene binding-site, avoid its action. Blankenship and Sisler (1989 and 1993) and Gong and Tian (1998) observed that NDB and DACP delayed the softening and ripening in apples. However, none of these products are commercially acceptable due to toxicity and manufacturing concerns (Fan et al., 1999).

The 1-methylcyclopropene (1-MCP or C_4H_6) is a potent inhibitor of the ethylene binding-site, acting as an antagonist (Sisler and Serek, 1997). The 1-MCP has been formulated into a powder that releases its active ingredient when mixed with

* Author for correspondence

water at 40-60°C. This nontoxic compound can be used at low concentrations (nL L^{-1}).
It has been reported that 1-MCP improved the shelf life of cut flowers and potted plants (Serek et al., 1994 and 1995; Porat et al., 1995; Sisler et al., 1996) and retarded the ripening of several climacteric fruits (Lelièvre et al., 1997b; Sisler and Serek, 1997; Abdi et al., 1998; Golding et al., 1998; Fan et al., 1999 and 2000; Feng et al., 2000; Jiang et al., 1999;). The objective of this work was to study the responses of custard apple to 1-MCP application during storage at room temperature.

MATERIAL AND METHODS

Custard apples (*Anonna squamosa* L.) were treated with Agrofresh™ , in powder form, having 0.14% of the active ingredient 1-MCP. The following 1-MCP concentrations were used: 0, 30, 90, 270 and 810 nL L^{-1} (0, 1.34, 4.02, 12.05 and 36.16 nmol L^{-1}, respectively). In order to achieve the above 1-MCP concentrations inside the chambers, Agrofresh™ powder was placed in sealed flasks (0.00016g of Agrofresh™ produce 100 nL L^{-1} of 1-MCP). Twenty milliliters of water at 50°C were added to the flasks, which were stirred until the complete dissolution of the compound. Then, the flasks were opened in the chambers, which were immediately sealed to avoid gas loss. Fruits were exposed to the gas released by the product during a 12-hour exposure period at 25°C in hermetic chambers. After 12 hours of treatment, the chambers were opened and the fruits were kept at room temperature (25°C).
The fruits were daily evaluated during four days at room temperature (25°C). Firmness was measured on two opposite sides of fruits by means of a 4mm-pointed tip penetrometer (TR Italy model FFT 196) and the results were expressed in kg. The soluble solids content (SSC) was determined through a digital refractometer and the results were expressed as Brix degrees. The fruits were considered ripe when firmness was $\leq$ 0.5 kg and the percentage of ripe fruits was calculated for each treatment.
A statistical analysis was carried out considering a completely randomized experimental design with five treatments, four replicates and five fruits per plot. The SANEST software (Zonta and Machado, 1984) was employed in the statistical analysis. The data were submitted to analysis of variance and the least significant differences were determined by using the Tukey's multiple range test.

RESULTS AND DISCUSSION

There was no significant interference of 1-MCP in the fruits' soluble solids content (SSC) during the storage period at 25°C (Figure 1). There was a notable increase in the SSC during exposure at room temperature. The SSC increased by almost 90% within a 4-day exposure period at 25°C after harvest, showing a continuous fruit ripening after harvest, which has been a characteristic of climacteric fruits. The increase in the SSC was probably due to the conversion of starch into soluble sugars, such as sucrose, fructose and glucose. Starch breakdown leading to soluble sugar production was reported by Paull et al. (1983) in soursop (*Annona muricata* L.) and by Prasanna et al. (2000) in custard apple. Fan et al. (1999) observed that non-treated apples did not differ from those treated with 1-MCP. The authors suggested that sensitivity to ethylene was not necessarily related to soluble solids accumulation in apple.
The fruits treated with 810 nL L^{-1} of 1-MCP presented higher firmness than control fruits during a 4-day period at 25°C (Figure 2). Firmness showed to be 50 to 60% higher in fruits treated with 1-MCP at this concentration when compared with non-treated fruits. The other concentrations were not effective at reducing the firmness loss. Fruit softening is considered to be one of the most sensible processes to ethylene in fruit ripening (Lelièvre et al., 1997a). Softening results from the breakdown of cell wall polysaccharides, which involves enzymatic activity. Paull et al. (1983) demonstrated an increase in the polygalacturonase (PG) and cellulase (endo-1.4, β-glucanase) activities during soursop (*Annona muricata* L.) ripening. More recently, Feng et al. (2000) verified that 1-MCP was capable of reducing the activity of these enzymes in avocado, thus retarding fruit softening. In the present work, 1-MCP at 810 nL L^{-1} probably reduced the activity of PG and cellulase, retarding the softening of custard apple.
As regards the ripening progress, evaluated through firmness of fruits kept at room temperature, there was a noticeable delay in ripening when were treated with 270 or 810 nL L^{-1} of 1-MCP (Table 1). The ripening percentage rate

(firmness ≤ 0.5 kg) observed for fruits treated or not with 30 or 90 nL L^{-1} varied from 70 to 86% after 4 days at 25°C while fruits treated with higher concentrations of 1-MCP presented ripening percentage figures around 40% in the same period.

We found that 1-MCP could effectively retard the softening process in custard apple and prolong the fruits' shelf life. The lengthening of the period in which fruits remain firm can allow fruits to be transported through longer distances, as well as extend the marketing period.

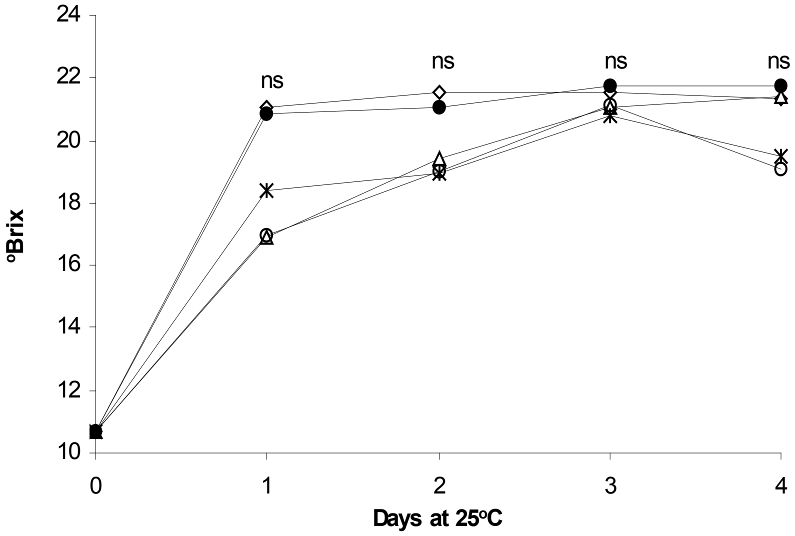

Figure 1 - Effect of 1-MCP on soluble solids content (°Brix) of custard apple (*Annona squamosa* L.) stored at 25°C. ◇ 0 nL L^{-1}; △ 30 nL L^{-1}; • 90 nL L^{-1}; ✳ 270 nL L^{-1}; o 810 nL L^{-1}. Means separated by Tukey test at P ≤ 0.05.

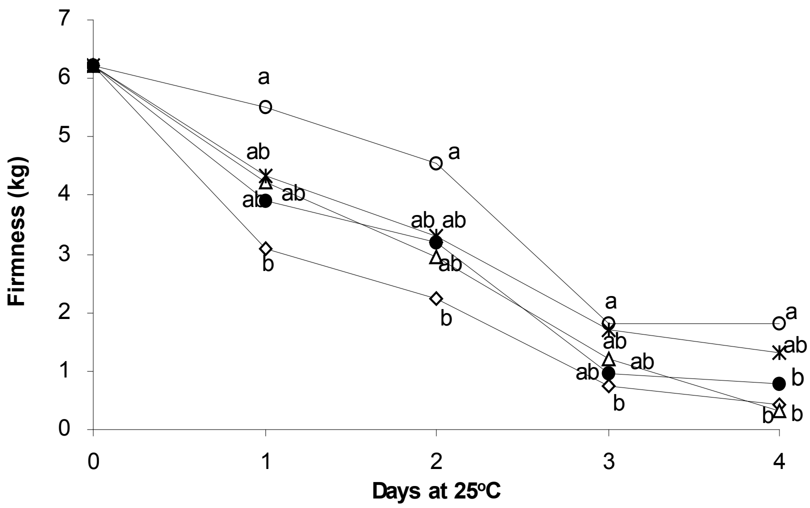

Figure 2 - Effect of 1-MCP on firmness (kg) of custard apple (*Annona squamosa* L.) stored at 25°C. ◇ 0 nL L^{-1}; △ 30 nL L^{-1}; • 90 nL L^{-1}; ✳ 270 nL L^{-1}; o 810 nL L^{-1}. Means separated by Tukey test at P ≤ 0.05.

Table 1 - Effect of 1-MCP on ripe fruits percentage for custard apple (*Annona squamosa* L) stored at 25°C.

1-MCP (nL L^{-1})	Days at 25°C			
	1	2	3	4
	--------- % of ripe fruits* --------			
0	10	16	32	80
30	0	16	41	86
90	11	19	43	70
270	0	18	41	41
810	0	15	25	42

*When firmness ≤ 0.5 kg, fruits were considered ripe.

RESUMO

A pinha ou fruta do conde (*Annona squamosa* L.) apresenta reduzida vida de prateleira após a colheita, devido à rápida perda de firmeza de polpa. Este processo está associado à produção e à ação do etileno. Com o objetivo de retardar o amolecimento e a evolução do amadurecimento, pinhas foram tratadas com o antagonista da ação do etileno 1-metilciclopropeno (1-MCP) nas concentrações de 0, 30, 90, 270 e 810 nL L^{-1} durante 12 horas a 25°C. Em seguida, os frutos foram armazenados a 25°C durante 4 dias. Durante este período foram determinados o teor de sólidos solúveis totais (SST), a firmeza de polpa e a porcentagem de frutos maduros (≤ 0,5kg de firmeza). Não houve efeito dos tratamentos sobre o teor de SST. Os frutos tratados com 810 nL L^{-1} de 1-MCP apresentaram maior firmeza de polpa que os frutos controle durante os 4 dias a 25°C. Frutos não tratados ou tratados com 30 ou 90 nL L^{-1} apresentaram evolução mais rápida do amadurecimento se comparados aos frutos tratados com 1-MCP em maiores concentrações. Este antagonista do etileno apresenta potencial para uso comercial em pinhas, visando uma retenção do amadurecimento e prolongamento da vida útil à temperatura ambiente.

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