1-methylcyclopropene (1-MCP) reduces water loss and extends shelf life of fruits of Rose apple (*Syzygium jambos* Alston) cv. Tabtim Chan

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1-methylcyclopropene (1-MCP) reduces water loss and extends shelf life of fruits of Rose apple (*Syzygium jambos* Alston) cv. Tabtim Chan.

Abstract — Introduction. Rose apple fruit ripens on the tree, has a thin peel, soft flesh and deteriorates quickly after harvest. Water loss contributes to rapid deterioration. 1-MCP can extend the postharvest life of non-climacteric fruits either directly through its effect as an ethylene blocker or through indirect effects. **Materials and methods**. We investigated the effect of 1-MCP (1 $\mu L \cdot L^{-1}$) on shelf life and quality of Rose apple fruits (*Syzygium jambos* Alston) cv. Tabtim Chan. Fruit were exposed to 1-MCP for (0, 6, 12, 18 or 24) h, then stored at (15 ± 1) °C for 12 days. Subsequently, we investigated the effect of 1-MCP (1 $\mu L \cdot L^{-1}$) for 12 h on fruit stored at 5 °C or 10 °C. Weight loss, skin colour, total soluble solids, fruit firmness and percentage of diseased fruit were measured during storage. **Results**. 1-MCP reduced weight loss from about 13% of initial weight to 6%, irrespective of the time of exposure. 1-MCP applied to fruit for 12 h or 18 h increased firmness from 3.2 N to 3.8 N and more than halved the percentage of fruit showing disease. Exposure to 1-MCP for 12 h or 18 h was optimum for reducing disease. 1-MCP for 12 h and storage at (10 ± 1) °C doubled shelf life to 24 days compared with fruit stored at the same temperature, but without 1-MCP. Storage at less than 10 °C did not extend shelf life any further. **Conclusion**. 1-MCP extended the shelf life of Rose apple fruit by reducing weight loss, maintaining flesh firmness and slowing disease development.

Thailand / *Syzygium jambos* / fruits / storage / keeping quality / postharvest physiology / disease control

Le 1-méthyle cyclopropène (1-MCP) réduit les pertes d'eau et prolonge la durée de conservation des fruits du jambosier (*Syzygium jambos* Alston) cv. Tabtim Chan.

Résumé — Introduction. La pomme rose, fruit du jambosier, mûrit sur un arbre, a une peau fine, une chair molle et se détériore rapidement après sa récolte. Sa déshydratation contribue à sa rapide détérioration. Le 1-MCP peut prolonger la vie post-récolte des fruits non climatériques, soit directement en agissant comme un bloqueur de l'éthylène, soit indirectement. **Matériel et méthodes**. Nous avons étudié l'effet du 1-MCP (1 $\mu L \cdot L^{-1}$) sur la durée de conservation et la qualité de pommes roses (*S. jambos* Alston) cv. Tabtim Chan. Les fruits ont été exposés au 1-MCP pendant (0, 6, 12, 18 ou 24) h, puis stockés à (15 ± 1) °C pendant 12 jours. Par la suite, nous avons étudié l'effet du 1-MCP (1 $\mu L \cdot L^{-1}$) pendant 12 h sur des fruits stockés à 5 °C ou à 10 °C. La perte de poids, la couleur de la peau, le total des solides solubles, la fermeté des fruits et le pourcentage de fruits atteints de maladies ont été suivis pendant leur stockage. **Résultats**. Le 1-MCP a réduit la perte de poids d'environ 13 % du poids initial à 6 %, quel qu'ait été le temps d'exposition. Le 1-MCP appliqué aux fruits pendant 12 h ou 18 h a augmenté la fermeté de 3,2 N à 3,8 N et a diminué de plus de la moitié le pourcentage de fruits présentant de maladie. L'exposition au 1-MCP pendant 12 h ou 18 h a été optimale pour la réduction des maladies. La durée de conservation des fruits traités au 1-MCP pendant 12 h puis stockés à (10 ± 1) °C a été doublée par rapport à celle des fruits entreposés à la même température, mais sans 1-MCP. Leur stockage à moins de 10 °C n'a pas permis d'augmenter davantage la durée de conservation. **Conclusion**. Le 1-MCP a augmenté la durée de vie de pommes roses en réduisant leur perte de poids, en maintenant la fermeté de leur pulpe et en ralentissant le développement de maladies.

Thaïlande / *Syzygium jambos* / fruits / stockage / aptitude à la conservation / physiologie après récolte / contrôle de maladies

1. Introduction

Rose apple is a fruit tree that grows in most regions of Thailand, but particularly in the Central Plain area. The fruit has a juicy sweet pulp and is one of many edible fruits in Thailand. Mature trees produce a large number of fruits, mostly in the rainy season (April–September). About 70 000 t of Rose apples were produced in Thailand in 2004, from 7 200 ha of bearing trees. In addition, this fruit tree is grown in a number of locations throughout the tropics [1].

After harvest, there is a problem in retaining the fresh condition of the fruit since its peel is quite thin and the flesh has a soft texture. Water is readily lost from fruits, which deteriorate quickly. This is a problem for local markets but it is worse if the fruit is sent to distant markets. Important features of the Rose apple are the loss of water from the fruit, loss of colour and the incidence of disease. Each of these contributes to the loss of fresh appearance. In addition, low temperature could be expected to extend shelf life, provided chilling damage was avoided.

Rose apple fruit ripen on the tree and are assumed to be non-climacteric [1]. Exogenous ethylene does not stimulate the ripening of non-climacteric fruits, but it can affect their rate of postharvest deterioration [2–4]. The effect of exogenous ethylene on Rose apple fruit is unknown but 1-methylcyclopropene (1-MCP), which blocks ethylene action in plant tissues [4], can increase the shelf life of non-climacteric fruit, such as strawberry [2, 3]. In addition to the direct effect of blocking the action of ethylene, there are indirect effects of 1-MCP, some of which are beneficial in postharvest management.

Treatment with 1-MCP reduced the rate of weight loss of avocado by 33% [5] but had no effect on the weight loss of citrus [6]. Avocado is a climacteric fruit with a leathery skin, while citrus is a non-climacteric fruit that has a relatively thick peel. Mozetic *et al.* found that 1-MCP treatment of sweet cherries cv. Lambert Compact did not retard colour change but it significantly reduced rotting at the highest concentration of 0.36 $\mu L \cdot L^{-1}$ and allowed the fruit to be stored at 2–4 °C for up to 12 days without deterioration [7]. The association between fruit decay and 1-MCP in strawberries is linked to the concentration of 1-MCP used, higher concentrations promoting decay and lower concentrations delaying it [8]. Jiang *et al.* established a negative correlation between the amount of phenolics and increased decay in strawberries that had been treated with 1-MCP [3]. In addition to different concentrations of 1-MCP, the length of time of the treatment is important. This is because 1-MCP binds to ethylene receptor sites that are present at the time of treatment, but if new receptor sites are being synthesised, then the 1-MCP loses its effectiveness over time.

Low temperature extends shelf life by reducing the respiration rate. However, low temperature is an expensive method of extending the shelf life of fruit and, if 1-MCP could be used as a partial substitute, this might allow fruit such as Rose apple to be marketed more widely than it is now. The use of 1-MCP may extend the shelf life of Rose apple and increase quality at the market.

The objective of our research was to study the impact of 1-MCP on Rose apple. We expected that the application of 1-MCP would extend the shelf life of Rose apple stored at (15 ± 1) °C and that storage at 5 °C would extend the storage life of Rose apple whether or not it had been treated with 1-MCP.

2. Materials and methods

At the Division of Plant Production Technology, Department of Agricultural Technology, Mahasarakham University, Northeast Thailand, we conducted two experiments on the effects of 1-MCP on quality of Rose apple fruits, cv. Tabtim Chan. Rose apple fruit for both experiments were obtained from a local market and had been harvested the previous day. The fruit were fully mature, thirty to thirty-five days after anthesis; they were fresh and red in colour. They had not received any treatments for disease control either at the farm or at the laboratory. The fruit were graded for uniform size

and colour and the absence of physical damage and disease.

In a first experiment (experiment 1), we examined the effect of time of exposure of the fruit to a concentration of 1 µL of 1-MCP·L^{-1}. The treatments were control (no 1-MCP), and exposure to 1-MCP for (6, 12, 18 or 24) h. The fruit were treated with EthylBloc^{TM} powder (EthyBloc, BioTechnologies for Horticulture, IL, USA), containing 0.14% 1-MCP active ingredient. 1-MCP was released from 100.80 mg of powder and 1.575 mL of deionised water was added to obtain 1 µL of 1-MCP·L^{-1}. The fruit were placed into 0.063 m^3 rigid polyethylene chambers and exposed to the gas at 20 °C. After the various treatment periods, the chamber was opened and fruit were placed in a basket (30 cm × 48 cm) (seven fruits/basket) and wrapped with perforated polypropylene plastic that contained 18 holes (1 cm × 1 cm) before being stored at (15 ± 1) °C and 80–85% relative humidity. The experiment was a completely randomised design with five replications of seven individual fruits per treatment.

All 35 fruits in each treatment were used for measurements of weight loss, expressed as a percentage of the initial fresh weight, skin colour, and visual assessment of disease (% of fruit diseased). Four fruits per treatment were used for the measurement of fruit firmness (N) and total soluble solids (TSS) in fruit flesh (°Brix). Measurements were made (0, 3, 6, 9, and 12) days after treatment.

Weight loss (%) was determined gravimetrically. Fruit firmness was measured at one point around the equator of the fruit using a penetrometer with a probe of 8 mm diameter and one fruit was measured in each replication. Disease incidence was assessed as the proportion of fruit showing signs of infection. Total soluble solids were measured with a hand-held refractometer (E type series 21 11-W10 Model N-1E, Japan). Flesh was taken from the central region of 1 fruit/replication. The colour of the skin was determined with the use of a chromameter (Minolta®, model CR-301, Japan) where the CIE lab system (L^*, a^* and b^*) was used to determine colour changes. Interpretations of the L^*, a^* and b^* values followed those of Bakker *et al.* [9], where L^* = the lightness of colour, with zero for black and 100 for white, a^* = red (positive) or green (negative) and b^* = yellow (positive) or blue-yellow (negative); then the a^* and b^* values were converted into hue angle (arctan b^*/a^*) and chroma ($\sqrt{a^{*2} + b^{*2}}$). Hue angle is an angle in a colour wheel of 360°, where 0° = red-purple, 90° = yellow, 180° = blue-green and 270° = blue. Chroma is the intensity or purity of the hue [10, 11].

In a second experiment (experiment 2), two 1-MCP treatments at 20 °C (control without 1-MCP and 1 µL of 1-MCP·L^{-1} for 12 h) were tested; then the fruits were stored at either 5 °C or 10 °C. 1-MCP was applied in the same manner as for the first experiment. After treatment, fruits were wrapped with polyvinyl chloride, put in trays and stored at either 5 °C or 10 °C at 80–85% RH. They were stored for 24 days and measurements of fruit quality were made (0, 6, 12, 18 and 24) days after treatment. The numbers of fruit used for measurements of quality parameters were similar to those in the first experiment but skin colour was not measured because no significant differences between treatment means were found in the first experiment. Each treatment had four replications in a completely randomised design, and each replication had seven fruits. The data were analysed using ANOVA [12] and significant differences between means were detected at $P = 0.05$. Data expressed as a percentage were transformed into inverse sine before analysis. The means were back-transformed for presentation in tables.

3. Results

In experiment 1 where fruit were stored at 15 °C, measurements stopped 12 days after treatment with 1-MCP as, at this stage, 90% of the control fruit were rated as 'diseased'. In contrast, in experiment 2 where fruit were stored at 5 °C or 10 °C, measurements continued until 24 days after treatment with 1-MCP and, at this stage, only 30% of the control fruit were rated as 'diseased'. During storage at 15 °C for 12 days in experiment 1, fruit lost weight, became softer and

Table I.
Weight loss (% of initial weight) of Rose apple fruits cv. Tabtim Chan as affected by time of exposure to 1 µL of 1-MCP·L^{-1} and stored at (15 ± 1) °C (experiment 1).

Time of exposure to 1-MCP (hours)	Storage duration (days)			
	3	6	9	12
0 (Control)	3.39 a	7.17 a	9.84 a	13.94 a
6	2.97 a	3.48 b	4.43 bc	5.92 b
12	2.59 a	2.21 b	3.33 c	5.02 b
18	2.50 a	3.60 b	3.24 c	6.46 b
24	2.77 a	3.64 b	5.11 b	6.76 b

Values followed by the same letters within each column indicate no significant difference between means at $P = 0.05$.

Table II.
Weight loss (% of initial weight) of Rose apple fruits cv. Tabtim Chan as affected by 1-MCP, storage temperature and storage duration (days). 1-MCP was applied at 1 µL of 1-MCP·L^{-1} for 12 h (experiment 2).

Treatments	Storage duration (days)			
	6	12	18	24
Control (no 1-MCP), 5 °C	2.95 a	7.27 a	9.74 a	13.05 a
Control (no 1-MCP), 10 °C	3.19 a	6.91 a	9.63 a	13.00 a
1-MCP, 5 °C	2.49 a	3.48 b	4.43 b	5.92 b
1-MCP, 10 °C	2.50 a	3.65 b	4.24 b	6.46 b

Different letters within a column indicate significant differences between means at $P = 0.05$.

increased in disease. There were no significant changes in either skin colour or the TSS in the flesh. Rose apple fruit stored at lower temperatures for 24 days in experiment 2 lost weight, became softer, increased their TSS and increased in disease.

1-MCP significantly reduced weight loss (%), compared with control, in both experiments (*tables I, II*) and the increased dosage of 1-MCP in experiment 1 had no effect (*table I*). After 12 days of storage in experiment 1, the control fruit had lost about 14% of their weight while those fruit treated with 1-MCP had lost 5% to 7%, less than half the amount of the control fruit. Significant differences between fruit treated with 1-MCP and controls did not appear until day 6 (*table I*). In experiment 2, 1-MCP halved weight loss, after 13 or more days of storage. The rate of weight loss differed between the two experiments but 1-MCP halved the rate of weight loss in each experiment.

In the control fruit of experiment 1, the fruit softened gradually and firmness decreased by 15% over 12 days (*table III*). A similar proportional change occurred in the control fruit in the first 12 days of experiment 2 but, by 24 days, flesh firmness had fallen by 53% (*table IV*). Treating fruit with 1-MCP for 12 h maintained fruit firmness for 12 days in experiment 1 (*table III*). This did not occur in experiment 2, where all fruit softened during the first 6 days of storage (*table IV*). Beyond this, the effect of 1-MCP

Table III.
Firmness of flesh tissues (N) of Rose apple fruits cv. Tabtim Chan as affected by time of exposure to 1 µL of 1-MCP·L^{-1} and stored at (15 ± 1) °C (experiment 1).

Time of exposure (hours)	Storage duration (days)				
	0	3	6	9	12
0 (control)	3.74 aA	3.64 aAB	3.47 aB	3.33 aB	3.19 bC
6	3.90 aA	3.76 aAB	3.93 aA	3.83a AB	3.21 bB
12	4.03 aA	4.07 aA	4.00 aA	3.95 aA	3.94 aA
18	4.09 aA	3.94 aAB	3.87 aB	3.81 aB	3.80 abB
24	4.01 aA	3.84 aAB	3.70 aAB	3.86 aB	3.59 abB

Different upper case letters within each row indicate significant differences between storage durations and different lower case letters within each column indicate significant differences between treatment means, each at $P = 0.05$.

Table IV.
Firmness of flesh tissue (N) of Rose apple fruits cv. Tabtim Chan as affected by 1-MCP, storage temperature and storage duration (days). 1-MCP was applied at 1 µL of 1-MCP·L^{-1} for 12 h (experiment 2).

Treatments	Storage duration (days)				
	0	6	12	18	24
Control (no 1-MCP), 5 °C	4.35 aA	3.96 aB	3.70 aB	3.45 aBC	2.04 bC
Control (no 1-MCP), 10 °C	4.69 aA	3.90 aB	3.79 aB	3.35 aBC	2.37 bC
1-MCP, 5 °C	4.45 aA	4.03 aB	4.01 aB	3.56 aC	3.43 aC
1-MCP, 10 °C	4.96 aA	3.98 aB	3.82 aB	3.76 aB	3.65 aB

Different upper case letters within a row indicate significant differences between storage times and different lower case letters within each column indicate significant differences between treatment means, each at $P = 0.05$.

in maintaining fruit firmness became evident only after 24 days of storage in experiment 2.

Disease was a major feature in the two experiments. After 3 days of storage, 13% to 15% of fruit were affected in experiment 1 (*table V*) and, in the control treatment, this increased to 90% after 12 days of storage. Initially, 1-MCP had no significant impact on disease incidence but differences began to appear after 9 days. After 12 days of storage, the fruit that had received 1-MCP for 12 h had only half the amount of diseased fruit compared with the other 1-MCP treatments (*table V*). In addition, it was only one-third of that of the control fruit. In experiment 2, disease developed at a much slower rate than in experiment 1 and 1-MCP decreased the incidence of diseased fruit (*table VI*). The effect of 1-MCP on disease development appeared after 6 days of storage at 5 °C but after 18 days at 10 °C.

Treatments did not affect colour change during 12 days of storage in experiment 1. The grand mean (± standard error) of L^* was 29.1 ± 0.2; of a^* was 18.9 ± 0.2 and of b^* was 10.4 ± 0.1. In addition, in experiment 1, treatments did not affect the TSS in the flesh. In experiment 2, TSS increased slightly with time in storage (*table VII*) but 1-MCP did not

Table V.
Disease incidence (% of fruit affected) of Rose apple fruits cv. Tabtim Chan as affected by time of exposure to 1 µL of 1-MCP·L^{-1} and stored at (15 ± 1) °C (experiment 1).

Time of exposure (hours)	Storage duration (days)			
	3	6	9	12
0 (control)	13.6 a	28.6 a	55.0 a	89.3 a
6	12.9 a	22.5 a	47.1 b	76.4 ab
12	12.9 a	20.7 a	30.7 e	38.6 c
18	14.3 a	19.3 a	41.4 d	67.1 b
24	15.0 a	25.0 a	45.7 c	75.7 ab

Different letters within each column indicate significant differences between means at $P = 0.05$.

Table VI.
Disease incidence (% of fruit affected) of Rose apple fruits cv. Tabtim Chan as affected by 1-MCP, storage temperature and storage duration (days). 1-MCP was applied at 1 µL of 1-MCP·L^{-1} for 12 h (experiment 2).

Treatments	Storage duration (days)			
	6	12	18	24
Control (no 1-MCP), 5 °C	7.1 a	12.9 a	20.7 a	31.4 a
Control (no 1-MCP), 10 °C	5.7 ab	10.7 ab	18.6 b	28.6 a
1-MCP, 5 °C	0.7 c	2.9 c	5.7 d	8.6 b
1-MCP, 10 °C	2.1 bc	5.7 bc	11.4 c	17.1 b

Different letters within a column indicate significant differences between treatment means at $P = 0.05$.

affect TSS until 24 days of storage when it maintained it at previous levels, compared with controls.

4. Discussion

The extension of shelf life of Rose apple fruits was indicated by reduced water loss, retention of skin colour, maintenance of TSS, retention of fruit firmness and the suppression of disease. Low temperature and treatment with 1-MCP extended shelf life of Rose apple cv. Tabtim Chan. In both experiments, the presence of 1-MCP halved the rate of water loss irrespective of the storage temperature. The impact of 1-MCP on fruit firmness and disease was more complex, showing a dose response (time × concentration) in experiment 1 and an interaction with temperature in experiment 2. There was no evidence that low temperature overrode the effects of 1-MCP in increasing shelf life. 1-MCP did not affect the skin colour and had only small effects on TSS.

Weight loss is dominated by the evaporation of water from the fruit. The rate of evaporation will be a function of the supply of water to the evaporating surface from inside the fruit, the vapour pressure gradient from the fruit to the air and the conductance

Table VII.
Total soluble solids (°Brix) of Rose apple fruits cv. Tabtim Chan as affected by 1-MCP, storage temperature and storage duration (days). 1-MCP was applied at 1 µL of 1-MCP·L^{-1} for 12 h (experiment 2).

Treatments	Storage duration (days)				
	0	6	12	18	24
Control (no 1-MCP), 5 °C	9.5 aA	9.6 aA	9.6 aA	10.3 aB	12.1 aC
Control (no 1-MCP), 10 °C	9.4 aA	9.5 aA	9.6 aA	10.2 aB	12.0 aC
1-MCP, 5 °C	9.5 aA	9.6 aA	9.9 aAB	10.7 aB	10.8 bB
1-MCP, 10 °C	9.6 aA	9.7 aA	9.8 aA	10.5 aB	10.6 bB

Different upper case letters within a row indicate significant differences between storage times and different lower case letters within a column indicate significant differences between treatment means, each at $P = 0.05$.

of the surface of the peel. We assume the vapour pressure gradient was similar for each treatment of 1-MCP but likely to be different at different temperatures. 1-MCP could block the action of ethylene in the surface cell layers [4], slow the ripening process, maintain the integrity of the tissues and reduce water loss. The diseased fruit in the trays were the likely main source of exogenous ethylene in this experiment.

The dose was important for fruit firmness, with fruit exposed to 1 µL of 1-MCP·L^{-1} for 12 hours being significantly firmer than those receiving 1-MCP for a shorter or longer time. This effect was most clear after 12 days of storage at 15 °C in experiment 1. Retention of firmness indicates a slowing of softening processes that may be indirectly affected by ethylene. Thus, increasing the dose of 1-MCP would be expected to delay the softening of the fruit, similar to responses observed in strawberry [3].

In non-climacteric fruit, 1-MCP may reduce or increase ethylene production, even though it binds to ethylene receptor sites in each case. In strawberries, Jiang *et al.* found that 1-MCP reduced ethylene production [3] but, in grapefruit (*Citrus paradisi*), Mullins *et al.* found that 1-MCP increased ethylene production, especially when the fruit were infected by the fungal pathogen *Penicillium digitatum* [13]. These differences may be related to different sensitivities of the signal transduction pathway for ethylene perception.

To sum up, based on the results of our two experiments, weight loss of Rose apple fruits can be reduced with 1-MCP. Rose apple fruits should be fumigated with 1-MCP before storage at 10 °C: a lower temperature showed no extra benefits. Rose apple fruits fumigated with 1 µL of 1-MCP·L^{-1} for 12 h or 18 h had significantly better fruit firmness and less disease than controls.

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El metilciclopropeno (1-MCP) reduce las pérdidas de agua y alarga la duración de conservación de los frutos del manzano rosa (*Syzygium jambos* Alston) cv. Tabtim Chan.

Resumen — Introducción. La manzana rosa, fruto del manzano rosa, madura sobre un árbol, tiene una piel fina y un mesocarpio carnoso blando; se deteriora rápidamente tras su cosecha. Su deshidratación contribuye a su rápido deterioro. El 1-MCP puede prolongar la vida postcosecha de los frutos no climatéricos, o bien directamente actuando como un bloqueador de etileno, o bien indirectamente. **Material y métodos**. Estudiamos el efecto del 1-MCP (1 $\mu L \cdot L^{-1}$) sobre la duración de conservación y sobre la calidad de las manzanas rosas (*S. jambos* Alston) cv. Tabtim Chan. Se expusieron los frutos al 1-MCP durante (0, 6, 12, 18 ó 24) h, a continuación se almacenaron a (15 ± 1) °C durante 12 días. Seguidamente, estudiamos el efecto del 1-MCP (1 $\mu L \cdot L^{-1}$) durante 12 h en frutos almacenados a 5 °C o a 10 °C. Durante su almacenamiento se estudiaron la pérdida de peso, el color de la piel, el número total de los sólidos solubles, la firmeza de los frutos y el porcentaje de frutos afectados por enfermedades. **Resultados**. El 1-MCP redujo la pérdida de peso de aproximadamente del peso inicial del 13% al 6%, independientemente del tiempo de exposición. El 1-MCP aplicado a los frutos durante 12 h o 18 h aumentó la firmeza de 3,2 N a 3,8 N y redujo a más de la mitad el porcentaje de frutos que presentaron enfermedades. La exposición al 1-MCP durante 12 h o 18 h fue óptima para la reducción de enfermedades. La duración de conservación fue del doble en aquellos frutos tratados con 1-MCP durante 12 h seguido de almacenamiento a (10 ± 1) °C en relación con aquellos otros frutos expuestos a la misma temperatura, pero sin 1-MCP. Su almacenamiento a menos de 10 °C no permitió que aumentase más la duración de conservación. **Conclusión**. El 1-MCP aumentó la duración de vida de las manzanas rosas reduciendo su pérdida de peso, manteniendo la firmeza de su pulpa y ralentizando el desarrollo de enfermedades.

Tailandia / *Syzygium jambos* / frutas / almacenamiento / aptitud para la conservación / fisiología postcosecha / control de enfermedades