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Quality attributes of cantaloupe (*Cucumis melo* L.) fruit under pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

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Abstract

Cantaloupe (*Cucumis melo* L.) is one of the most delicious fruits popularly cultivated in tropical regions due to its sweet-juicy taste, attractive flavor and bioactive composition. Extending cantaloupe shelf-life during handling and distribution is very necessary to upgrade its commercial value. Methyl jasmonate (MJeA) and salicylic acid (SA) are bio-regulators widely applied on either pre- or post-harvest to extend the shelf life and maintain fruit quality during storage. In this investigation, the possibility of both pre-harvest (7 days before harvesting) via spraying and post-harvest (immediately after harvesting) evaluated by dipping on cantaloupe fruit by either MJeA (3 mM) or SA (3 mM) separately; in combination with MJeA/SA (1.5/1.5 mM/mM) for 30 s. These fruits were kept at 24±0.5 °C for 28 days of storage. In 7 day-interval, fruits were sampled to verify firmness, weight loss, decay rate, total soluble solid, carotenoid, vitamin C, total phenolic content, total flavonoid content. Results revealed that there was a significant difference in quality attributes between the treated samples and the control ones. However, there was no significant difference in quality attributes on either pre-harvest or post-harvest treatments by MeJA and SA reagents. Incorporation of MJeA/SA (1.5/1.5 mM/mM) by either pre-harvest or post-harvest maintained the most firmness (52.10±0.11 N or 52.37±0.08 N), total soluble solid (18.08±0.05 °Brix or 18.15±0.04 °Brix), carotenoid (46.97±0.02 µg/100 g or 47.10±0.03 µg/100 g), vitamin C (26.04±0.02 mg/100 g or 26.17±0.02 mg/100 g), total phenolic content (117.86±0.05 mg GAE/100 g or 119.75±0.09 mg GAE/100 g), total flavonoid content (84.04±0.02 mg QE/100 g or 84.20±0.02 mg QE/100 g) as well as the least weight loss (3.74±0.01% or 3.66±0.03%) and decay rate (1.42±0.01% or 1.26±0.03%) at the end of 28 days of storage. The synergistic effect of MeJA and SA would be a promising alternative to preserve cantaloupe fruit quality with a long shelf life.

Keywords

Cantaloupe, methyl jasmonate, post-harvest, pre-harvest, salicylic acid

Introduction

Horticultural crops are an important source of carbohydrates, proteins, organic acids, vitamins and minerals for human nutrition. Methyl jasmonate (MeJA) is contributing important properties in modifying stress reaction and crop growth (1) and enabled numerous protective signaling behaviors to release extra metabolites (2). MJeA is used to postpone peach bloom, flowering and fruiting (3). And crop cultivation includes preservative structure establishment, the inspiration of crop protection against biotic and abiotic stresses and growth retardation in stem and baby sprout (4). MJeA is demonstrated to be effective as a natural crop development regulator to activate self-defense, suppress postharvest dysfunction, amassed phenolics in numerous horticultural crops such as mango, apple, papaya, cherry, blackberry, bayberry, peach, pomegranate, raspberry, strawberry, pear and mandarin (5-17).

Salicylic acid (SA) is a naturally effective reagent responsible for retarding ethylene emission, microbial load and fungal dispersion (18-19). SA plays a key role in leaf maturity (20), flowering (21), grain germination (22), provision in root moisture absorption (23), alleviation of thermal stress (24), bio-metabolism of heavy metal residue (25), retardation of chilling injury, adaption to salt tolerance (26), adjustment to cold resistance (27) and in proliferation of reactive oxygen species and nitrogen substances leading to enable various pathways to produce sub metabolites in sequence obtained protection (28). SA has been proved to be appropriate to improve pre- and post-harvest quality of different kinds of fruit such as banana (29), sweet pepper (30), cherry (8), peach (31), plum (32), guava (33), mangosteen (34), mandarin (17, 35). SA is slowdown the senescence by retardation of ethylene biosynthesis (36). SA agent was proven to discourage 1-aminocyclopropane-1-carboxylic acid synthase and 1-aminocyclopropane-1-carboxylic acid oxidase in paddy (37). The ultimate impact of salicylic acid on crops was based on its load, species, evolution period and external factors (38).

Africa was supposed to be the region of domestication for cantaloupe (*Cucumis melo*) melon. There are two subspecies in cantaloupe, *C. melo* subsp. *melo* having pilose or lanate ovaries (long, spreading soft hairs) and *C. melo* subsp. *agrestis* having ovaries with short, appressed hairs. It is one of the best well-known fruits widely cultivated in humid, tropical and subtropical locations (39) and is greatly valued due to its unique taste, aroma, texture firmness and therapeutic advantages for health such as hematoma and hypertension mostly due to ascorbic acid, carotene, folic acid and potassium (40). Cantaloupe is ranked 4th consumer acceptance in the list of the most preferred fresh fruits with impressive nutrients in the world market (41). It is easily distinguished by its netted surface and highly valued due to wonderful nutritional proximate with a rich source of phytochemical constituents such as minerals, polyphenols, favonoids, saponins and vitamins especially carotenoids (42-45). This fruit contributed to valuable medicinal characteristics against numerous ailments like anti-cancer, anti-hypothyroidism, anti-diabetic, hepato-protective and antibiotic (46-49).

There have been several notable studies on the preservation of cantaloupe fruit. Polyethylene bag and 3 min immersion in hot water at 60 °C could reduce weight loss and decay in netted cantaloupe during 28 days of cool storage (50). Cantaloupe is only stable for three weeks at 10 °C at 90±5% relative humidity (51). Postharvest hot water immersion is slowdown decay by improving pathogen defence and retaining texture hardness in cantaloupe fruit (52). Hydro-cooling is efficient in maintaining the texture firmness and dry matter of cantaloupe (53). The 1-methylcyclopropene (1-MCP) has a significant improvement on quality fresh-cut muskmelon fruit during 7 days of preservation (54). Pre-cooling contributed to more desirable quality attributes of cantaloupe during storage at 15 °C with 90-95% relative humidity than that of control (55). 1-MCP at 75 ppm extended the stability and improved phytochemical attributes of cantaloupe fruit for 28 days (56).

To improve the quality properties of cantaloupe fruit, the purpose of our research focused on the implementation of MJeA and SA in either individual or combination in the pre-harvest and post-harvest treatment of cantaloupe fruit in respect of its quality attributes such as firmness, weight loss, decay rate, total soluble solid, carotenoid, vitamin C, total phenolic content and total flavonoid content during 28 days of storage.

Materials and Methods

Material

The experiments were performed on cantaloupe fruits in both the orchard and the warehouse in Binh Phuoc province, Vietnam. All fruits were in uniform size (2,500±50 g per fruit), free from disease or scar. Chemical reagents were all analytical or HPLC grade. Methyl jasmonate, salicylic acid, standard β-carotene, hexane, Folin-Ciocalteu reagent, 2,6-dichlorophenol indophenols were purchased from Sigma Aldrich (USA). Methanol was supplied from Fisher Scientific (USA). Standard quercetin, gallic acid, aluminum chloride, sodium acetate, sodium carbonate were purchased from Merck (Germany).

Methodology

The fruits were treated at either pre-harvest (7 days before harvesting) via spraying or post-harvest (immediately after harvesting) at 3.0 mM concentration of methyl jasmonate and 3.0 mM salicylic acid in individual dose or in combination of jasmonate/salicylic acid (1.5/1.5 mM/mM) for 30 s. Each treatment was arranged in triplicate including 15 fruits. After treatments, they were stored at 24±0.5 °C for 28 days. In 7 day-interval, samples were taken to examine firmness, weight loss, decay rate, total soluble solid, carotenoid, vitamin C, total phenolic content, total flavonoid content.

Firmness (N) was examined by texture analyzer (Stable Micro Systems, model: TA.XT*plusC*). Weight loss (%) was estimated by the difference of the initial weight and the sampled-interval weight. Decay rate (%) was estimated by the number of decay fruits per the whole number of experimental fruits. Total soluble solid (°Brix) was checked by hand-held refractometer (Atago, model: Master-53M). Carotenoid (µg/100 g) was determined by high-performance liquid chromatography method (Techno, model: HPLC 580) using a polymeric C30 column. Vitamin C (mg/100 g) was quantified by using a 2,6-dichlorophenol indophenol visual titration method. Total phenolic content (mg GAE/100g) was examined by using Folin–Ciocalteu assay. The optical density was measured by the absorbance at 765 nm using a spectrophotometer (Mettler Toledo, model: UV5) (57). Total flavonoid content (mg GE/100g) was examined by the aluminum calorimetric method. The optical density was measured by absorbance at 415 nm using a spectrophotometer (Mettler Toledo, model: UV5) (58).

Statistical analysis

The experiments were run in triplicate with different groups of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Stat graphics Centurion version XVI. The mean value($\bar{x}$) and standard deviation (2*s*) of a set of data are obtained by analysis of random samples estimating the population statistics. 95% of results would be expected to lie within the range we describe the lower and upper bounds of this range as the 95% confidence limits of the results. The differences between the pickling samples are analyzed using a one-way analysis of variance (ANOVA). A significant value is set at a 95% confidence interval (p 0.05). If significant differences are found, then post hoc analysis is performed using Duncan's multiple range tests. .

Results and Discussion

Firmness of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Fruit firmness was decreased in all treatments including control during storage. There was the greatest reduction of texture firmness on the control (53.72±0.07 N down to 49.75±0.13 N). Meanwhile, a gradual reduction of texture firmness was recorded at samples treated by MeJA or SA during 28 days of storage. The highest firmness retention was noticed at either the pre-harvest-MeJA/SA 1.5/1.5 mM/mM (53.73±0.05 N down to 52.10±0.11 N) or the post-harvest-MeJA/SA 1.5/1.5 mM/mM (53.73±0.08 N down to 52.37±0.08 N) (Table 1). SA and MeJA were proved to be effective in lowering the senescence and limiting the ripening and emission of ethylene, as an aftermath to improve texture firmness. Firmness of fresh-cut pineapple was highly maintained by MeJA submersion or fumigation during 6 days of storage (59). SA and its derivatives were commonly utilized to improve pre- and post-harvest firmness of peach, cherry and strawberry in preservation (60-62). 2 mmol/L SA effectively maintained the fruit firmness of apricot in 8 days of storage (63). 16 µmol MeJA treatment loquat showed the highest retention of fruit firmness during storage (64). 0.2 mmol/L methyl jasmonate and 2 mmol/L salicylic acid comprehensively maintained apricot fruit firmness (65). 0.25 mM MeJA and 4 mM SA significantly preserved firmness of strawberry (66). Salicylic acid treatment decreased pectin methyl esterase resulting in texture firmness retention (67).

Table 1. Firmness (N) of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Storage (days)	0	7	14	21	28
Control	53.72±0.07[a]	52.24±0.09[c]	51.35±0.12[c]	50.57±0.07[c]	49.75±0.13[d]
Pre-harvest – MeJA 3.0 mM	53.69±0.11[a]	52.75±0.13[bc]	51.83±0.09[bc]	51.06±0.11[bc]	50.11±0.09[cd]
Pre-harvest – SA 3.0 mM	53.70±0.09[a]	52.81±0.11[bc]	51.94±0.10[bc]	51.24±0.09[bc]	50.63±0.12[c]
Pre-harvest – MeJA/SA 1.5/1.5 mM/mM	53.73±0.05[a]	53.36±0.08[ab]	52.84±0.07[ab]	52.65±0.08[ab]	52.10±0.11[ab]
Post-harvest – MeJA 3.0 mM	53.68±0.10[a]	53.09±0.09[b]	52.15±0.13[b]	51.77±0.10[b]	51.05±0.07[bc]
Post-harvest – SA 3.0 mM	53.71±0.06[a]	53.14±0.07[b]	52.23±0.06[b]	51.90±0.09[b]	51.63±0.11[b]
Post-harvest – MeJA/SA 1.5/1.5 mM/mM	53.73±0.08[a]	53.67±0.08[a]	53.07±0.10[a]	52.76±0.07[a]	52.37±0.08[a]

Figures are the mean of three replications; Figures in a row followed by the same letter/s are not differed significantly (α = P=0.05)

Weight loss of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

The control sample showed the highest weight loss (2.25±0.03% to 7.71±0.01%). Meanwhile, a slight increment of weight loss was recorded at samples treated by MeJA or SA during 28 days of storage. The lowest weight loss was noticed at either the pre-harvest-MeJA/SA 1.5/1.5 mM/mM (1.15±0.00% to 3.74±0.01%) or the post-harvest-MeJA/SA 1.5/1.5 mM/mM (1.09±0.02% to 3.66±0.03%) (Table 2). The antisenescent and stabilization principle of cellular wholesomeness by both MeJA and SA were responsible for reducing weight loss (62). SA minimized fruit weight loss by shutting stomata of mandarin (68). Four concentrations of salicylic acid (0.5, 1, 1.5 and 2 mM) were experimented on fresh apricot by dipping and observed at 2-day intervals. 2 mmol/L SA treatment provided the minor fruit weight loss of apricot in 8 days of storage (63). Peach fruit was harvested at a firm-mature stage and treated with 1, 10, 100 or 500 µmol/L MeJA vapor at 20 °C for 24 hr before being stored at 25 °C for 8 days. 1-100 µmol MeJA treatment effectively controlled weight loss of peach fruit (64). Three concentrations of MeJA (0.1, 0.2 and 0.4 mmol/L) and SA (0.5, 1, 2 mmol/L for SA) were treated on apricot fruit for 15 min. 0.2 mmol/L methyl jasmonate and 2 mmol/L salicylic acid greatly controlled apricot fruit weight loss (65). Strawberry fruits were treated with 2 and 4 mM salicylic acid (SA) and methyl jasmonate at 0.25 and 0.50 mM (MeJA). 0.25 mM MeJA and 4 mM SA significantly suppressed weight loss of strawberry (66).

Decay rate of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

The control sample showed the highest decay rate

Table 2. Weight loss (%) of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Storage (days)	7	14	21	28
Control	2.25±0.03[a]	3.85±0.02[a]	5.20±0.00[a]	7.71±0.01[a]
Pre-harvest – MeJA 3.0 mM	2.01±0.01[ab]	2.59±0.00[b]	3.75±0.03[b]	5.09±0.02[b]
Pre-harvest – SA 3.0 mM	1.97±0.02[ab]	2.48±0.01[b]	3.62±0.00[b]	4.92±0.03[b]
Pre-harvest – MeJA/SA 1.5/1.5 mM/mM	1.15±0.00[bc]	1.73±0.02[c]	2.57±0.03[c]	3.74±0.01[c]
Post-harvest – MeJA 3.0 mM	1.72±0.03[b]	2.25±0.01[bc]	3.17±0.00[bc]	4.33±0.02[bc]
Post-harvest – SA 3.0 mM	1.66±0.01[b]	2.16±0.03[bc]	3.02±0.02[bc]	4.21±0.01[bc]
Post-harvest – MeJA/SA 1.5/1.5 mM/mM	1.09±0.02[c]	1.65±0.00[c]	2.43±0.01[c]	3.66±0.03[c]

Figures are the mean of three replications; Figures in a row followed by the same letter/s are not differed significantly (α = P=0.05)

(0.51±0.05% to 4.34±0.05%). Meanwhile, a minor accumulation of decay rate was recorded at samples treated by MeJA or SA during 28 days of storage. The lowest decay rate was noticed at the pre-harvest-MeJA/SA 1.5/1.5 mM/mM (0.10±0.02% to 1.42±0.01%) or the post-harvest-MeJA/SA 1.5/1.5 mM/mM (0.07±0.01% to 1.26±0.03%) (Table 3). The mechanism of SA in limiting postharvest rotten was due to its function in generating hydrogen peroxide as a signal segment to trigger botanical defense responses against pathogen invasion (19). MeJA was also proven to create its activation of resistant pathways (69). 1 µM MeJA treatment via fumigation greatly inhibited decay by *Botrytis* mycelial growth in strawberry (70). Pathogen proliferation on celery and pepper was retarded by MeJA (71). Green fungus on grapefruit was remarkably minimized by immersion 1 – 50 µM MeJA (72). Fumigation of 100 µM MeJA on raspberry effectively eradicated decay during 10 days of 10 °C storage (73). Vapor MeJA (0.025 – 0.1 µl/L) decreased the degree, hurt count and hurt circle of *Botrytis* (74). Strawberry was highly protected from decay during 12 days at 7.5 °C through 100 mM MeJA fumigation (75). MeJA fumigation limited decay on peach fruit in 8 days of storage (64). Implementation of salicylic acid with calcium effectively reduced decay on apple fruit either at the pre- or post-harvest period (76). MeJA retarded decay caused by *Botrytis cinerea* on strawberry (77-79). 0.25 mM MeJA and 4 mM SA significantly suppressed weight loss of strawberry (66). 10 mM MeJA and AS immersion remarkably minimized the degree of the lesion induced by *Colletotrichum* sp. in mango fruit (80).

Table 3. Decay rate (%) of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Storage (days)	7	14	21	28
Control	0.51±0.05[a]	1.57±0.06[a]	2.70±0.03[a]	4.34±0.05[a]
Pre-harvest – MeJA 3.0 mM	0.23±0.02[b]	1.03±0.03[b]	1.65±0.02[b]	2.90±0.03[b]
Pre-harvest – SA 3.0 mM	0.20±0.00[b]	0.97±0.01[b]	1.48±0.03[b]	2.77±0.02[b]
Pre-harvest – MeJA/SA 1.5/1.5 mM/mM	0.10±0.02[c]	0.34±0.02[c]	0.76±0.00[c]	1.42±0.01[c]
Post-harvest – MeJA 3.0 mM	0.16±0.01[bc]	0.70±0.03[bc]	1.12±0.01[bc]	2.14±0.03[bc]
Post-harvest – SA 3.0 mM	0.13±0.02[bc]	0.61±0.00[bc]	1.04±0.02[bc]	2.01±0.00[bc]
Post-harvest – MeJA/SA 1.5/1.5 mM/mM	0.07±0.01[c]	0.21±0.01[c]	0.64±0.00[c]	1.26±0.03[c]

Figures are the mean of three replications; Figures in a row followed by the same letter/s are not differed significantly (α = P=0.05)

Total soluble solid of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Sucrose-phosphate synthase has been highly accounted for soluble solid biosynthesis in fruit maturity (81). Methyl salicylic acid is slowed down ethylene production and sucrose-phosphate synthase reaction therefore it reduced total soluble solid biosynthesis (82). Moreover, SA retarded the reaction of cell wall catalyzing enzymes hence the total soluble solid would not increase (83). There was a greatest reduction of total soluble solid on the control (18.46±0.03 °Brix down to 14.15±0.06 °Brix). Meanwhile a gradual reduction of total soluble solid was recorded at samples treated by MeJA or SA during 28 days of storage. The highest total soluble solid retention was noticed at either the pre-harvest-MeJA/SA 1.5/1.5 mM/mM (18.47±0.03 °Brix down to 18.08±0.05 °Brix) or the post-harvest-MeJA/SA 1.5/1.5 mM/mM (18.52±0.01 °Brix down to 18.15±0.04 °Brix) (Table 4). Our result was similar to other findings in different literatures. MeJA strongly preserved total soluble solid in strawberry superior to the control (75). MeJA comprehensively stabilized a great amount of total soluble solid of peach during cold storage (11). 0.1 mmol/L MeJA treatment greatly preserved total soluble solid in peach by inhibiting the composition of cell wall via modification of cell wall hydrolyzing enzymes (12). 0.2 mmol/L methyl jasmonate and 2 mmol/L salicylic acid comprehensively preserved total solid content of apricot fruit (65). Total soluble solid content in strawberry was greatly improved by 0.25 mM

MeJA treatment (66). There was a significant enhancement of total soluble solid (Brix) in orange by MeJA (84) and in apricot as well as mandarin by SA (35, 65) treatments.

Table 4. Total soluble solid (ºBrix) of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Storage (days)	0	7	14	21	28
Control	18.46±0.03[a]	16.95±0.04[c]	16.14±0.06[c]	15.29±0.03[c]	14.15±0.06[c]
Pre-harvest – MeJA 3.0 mM	18.49±0.02[a]	17.92±0.06[b]	17.68±0.05[b]	17.15±0.04[b]	16.75±0.03[b]
Pre-harvest – SA 3.0 mM	18.45±0.01[a]	17.97±0.05[b]	17.75±0.04[b]	17.21±0.05[b]	16.89±0.04[b]
Pre-harvest – MeJA/SA 1.5/1.5 mM/mM	18.47±0.03[a]	18.41±0.06[a]	18.37±0.03[a]	18.20±0.02[a]	18.08±0.05[a]
Post-harvest – MeJA 3.0 mM	18.50±0.02[a]	18.09±0.04[ab]	17.96±0.05[ab]	17.81±0.03[ab]	17.51±0.03[ab]
Post-harvest – SA 3.0 mM	18.49±0.00[a]	18.15±0.03[ab]	18.03±0.02[ab]	17.90±0.04[ab]	17.64±0.02[ab]
Post-harvest – MeJA/SA 1.5/1.5 mM/mM	18.52±0.01[a]	18.48±0.04[a]	18.40±0.05[a]	18.29±0.02[a]	18.15±0.04[a]

Figures are the mean of three replications; Figures in a row followed by the same letter/s are not differed significantly (α = P=0.05)

Carotenoid of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

There was the greatest reduction of carotenoid content on the control (48.70±0.02 µg/100 g down to 42.09±0.03 µg/100 g). Meanwhile, a gradual reduction of carotenoid content was recorded at samples treated by MeJA or SA during 28 days of storage. The highest carotenoid retention was noticed at either the pre-harvest-MeJA/SA 1.5/1.5 mM/mM (48.69±0.02 µg/100 g down to 46.97±0.02 µg/100 g) or the post-harvest-MeJA/SA 1.5/1.5 mM/mM (48.70±0.00 µg/100 g down to 47.10±0.03 µg/100 g) (Table 5). Our result was similar to other finding in different literatures. MeJA treatment strongly enhanced β-carotene content in apple (85). Slight treatment of jasmonate on tomato fruit at the end period of maturity was important to support lycopene biosynthesis (86). SA preharvest treatment increased carotenoid accumulation in orange (87). MeJA treatment improved the lycopene accumulation via accelerating carotenoid biosynthetic route gene exhibition (88). SA treatment was beneficial to improve the carotenoid content in mandarin fruit (89). More lycopene accumulation was strictly correlated with high salicylic acid concentration (67).

Table 5. Carotenoid content (µg/100 g) of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Storage (days)	0	7	14	21	28
Control	48.70±0.02[a]	47.34±0.05[c]	45.17±0.03[c]	43.81±0.02[c]	42.09±0.03[c]
Pre-harvest – MeJA 3.0 mM	48.67±0.00[a]	47.76±0.03[b]	46.92±0.02[b]	46.26±0.03[b]	45.67±0.01[b]
Pre-harvest – SA 3.0 mM	48.71±0.01[a]	47.81±0.04[b]	47.08±0.03[b]	46.39±0.02[b]	45.80±0.00[b]
Pre-harvest – MeJA/SA 1.5/1.5 mM/mM	48.69±0.02[a]	48.40±0.02[a]	48.04±0.02[a]	47.73±0.04[a]	46.97±0.02[a]
Post-harvest – MeJA 3.0 mM	48.72±0.03[a]	48.05±0.03[ab]	47.55±0.04[ab]	47.04±0.01[ab]	46.19±0.02[ab]
Post-harvest – SA 3.0 mM	48.68±0.02[a]	48.12±0.04[ab]	47.69±0.01[ab]	47.15±0.02[ab]	46.28±0.00[ab]
Post-harvest – MeJA/SA 1.5/1.5 mM/mM	48.70±0.00[a]	48.49±0.01[a]	48.13±0.03[a]	47.86±0.00[a]	47.10±0.03[a]

Figures are the mean of three replications; Figures in a row followed by the same letter/s are not differed significantly (α = P=0.05)

Ascorbic acid of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

There was the greatest reduction of ascorbic acid content on the control (27.60±0.01 mg/100 g down to 13.07±0.02 mg/100 g). Meanwhile, a gradual reduction of ascorbic acid content was recorded at samples treated by MeJA or SA during 28 days of storage. The highest ascorbic acid retention was noticed at either the pre-harvest-MeJA/SA 1.5/1.5 mM/mM (27.64±0.02 mg/100 g down to 26.04±0.02 mg/100 g) or the post-harvest-MeJA/SA 1.5/1.5 mM/mM (27.62±0.01 mg/100 g down to 26.17±0.02 mg/100 g) (Table 6). Our result was similar to other finding in different literatures. Maize seeds treated with 112 µM MeJA showed better resistant to drought with abundant vitamin C content (90). Spraying 0.1 mM MeJA before drought lasting stabilized the vitamin C content in strawberry leaf (91). Methyl jasmonate was proven to trigger the biosynthesis of ascorbic acid in plant tissue (92). A significant improvement in Ascorbic acid was observed on the 0.5 mM MeJA treated strawberry (93). Ascorbic acid content of strawberry was highly maintained by 0.25 mM MeJA and 4 mM SA treatment (66).

Total phenolic content of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

There was the greatest reduction of total phenolic content on the control (149.25±0.04 mg GAE/100 g down to 69.27±0.07 mg GAE/100 g). Meanwhile, a gradual reduction of total phenolic content was recorded at samples treated by MeJA or SA during 28 days of storage. Biochemical changes could be due to the respiration process. The highest total phenolic content retention was noticed at either the pre-harvest-MeJA/SA 1.5/1.5 mM/mM (148.97±0.03 mg GAE/100 g down to 117.86±0.05 mg GAE/100 g) or the post-

Table 6. Ascorbic acid (mg/100 g) of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Storage (days)	**0**	**7**	**14**	**21**	**28**
Control	27.60±0.01[a]	26.28±0.02[c]	25.40±0.02[c]	23.21±0.00[c]	22.07±0.02[c]
Pre-harvest – MeJA 3.0 mM	27.63±0.00[a]	26.77±0.03[b]	26.29±0.01[b]	25.64±0.02[b]	24.95±0.01[b]
Pre-harvest – SA 3.0 mM	27.59±0.03[a]	26.83±0.01[b]	26.36±0.03[b]	25.78±0.01[b]	25.08±0.03[b]
Pre-harvest – MeJA/SA 1.5/1.5 mM/mM	27.64±0.02[a]	27.49±0.03[a]	27.21±0.02[a]	26.85±0.00[a]	26.04±0.02[a]
Post-harvest – MeJA 3.0 mM	27.58±0.01[a]	27.09±0.02[ab]	26.84±0.01[ab]	26.14±0.02[ab]	25.53±0.00[ab]
Post-harvest – SA 3.0 mM	27.61±0.03[a]	27.15±0.01[ab]	26.95±0.00[ab]	26.28±0.01[ab]	25.69±0.03[ab]
Post-harvest – MeJA/SA 1.5/1.5 mM/mM	27.62±0.01[a]	27.51±0.03[a]	27.30±0.02[a]	26.93±0.00[a]	26.17±0.02[a]

Figures are the mean of three replications; Figures in a row followed by the same letter/s are not differed significantly (α = P=0.05)

harvest-MeJA/SA 1.5/1.5 mM/mM (149.09±0.03 mg GAE/100 g down to 119.75±0.09 mg GAE/100 g) (Table 7). Our result was similar to other findings in different literatures. Treatment of MeJA (1 mM) and SA (2 mM) greatly maintained the phenolic content by activating the reaction of phenylalanine ammonia lyase (8). 0.1 mM MeJA strongly improved phenolic and flavonoid content in raspberry (94). 0.5 mM SA treatment significantly improved the total phenolic content (95). MeJA was proven to be essential for preservation of oranges and bayberry (84). SA was beneficial for storage of mandarin, peaches and pineapple (31, 35, 96).

Table 7. Total phenolic content (mg GAE/100 g) of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Storage (days)	**0**	**7**	**14**	**21**	**28**
Control	149.25±0.04[a]	95.48±0.11[c]	87.15±0.14[c]	80.45±0.12[c]	69.27±0.07[c]
Pre-harvest – MeJA 3.0 mM	148.89±0.03[a]	99.27±0.17[b]	92.89±0.13[b]	87.51±0.09[b]	80.09±0.06[b]
Pre-harvest – SA 3.0 mM	148.90±0.01[a]	101.46±0.15[b]	93.72±0.17[b]	88.73±0.15[b]	81.23±0.09[b]
Pre-harvest – MeJA/SA 1.5/1.5 mM/mM	148.97±0.03[a]	136.83±0.10[a]	129.81±0.12[a]	122.97±0.11[a]	117.86±0.05[a]
Post-harvest – MeJA 3.0 mM	149.12±0.02[a]	114.90±0.16[ab]	107.33±0.13[ab]	100.47±0.12[ab]	95.08±0.08[ab]
Post-harvest – SA 3.0 mM	149.05±0.05[a]	119.41±0.14[ab]	110.27±0.14[ab]	102.16±0.10[ab]	96.34±0.06[ab]
Post-harvest – MeJA/SA 1.5/1.5 mM/mM	149.09±0.03[a]	137.41±0.19[a]	130.25±0.11[a]	124.60±0.14[a]	119.75±0.09[a]

Figures are the mean of three replications; Figures in a row followed by the same letter/s are not differed significantly (α = P=0.05)

Total flavonoid content of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

There was the greatest reduction of total flavonoid content on the control (90.13±0.02 mg QE/100 g down to 65.28±0.02 mg QE/100 g). Meanwhile, a gradual reduction of total flavonoid content was recorded at samples treated by MeJA or SA during 28 days of storage. The highest total flavonoid content retention was noticed at either the pre-harvest-MeJA/SA 1.5/1.5 mM/mM (90.11±0.00 mg QE/100 g down to 84.04±0.02 mg QE/100 g) or the post-harvest-MeJA/SA 1.5/1.5 mM/mM (90.15±0.00 mg QE/100 g down to 84.20±0.02 mg QE/100 g) (Table 8). Our result was similar to

Table 8. Total flavonoid content (mg QE/100 g) of cantaloupe affected by pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid

Storage (days)	**0**	**7**	**14**	**21**	**28**
Control	90.13±0.02[a]	78.49±0.03[c]	74.25±0.02[c]	71.54±0.03[c]	65.28±0.02[c]
Pre-harvest – MeJA 3.0 mM	90.17±0.01[a]	81.23±0.04[b]	80.76±0.01[b]	79.39±0.02[b]	75.89±0.01[b]
Pre-harvest – SA 3.0 mM	90.08±0.03[a]	81.49±0.03[b]	80.93±0.03[b]	79.48±0.00[b]	76.13±0.03[b]
Pre-harvest – MeJA/SA 1.5/1.5 mM/mM	90.11±0.00[a]	88.35±0.02[a]	86.05±0.00[a]	85.43±0.03[a]	84.04±0.02[a]
Post-harvest – MeJA 3.0 mM	90.19±0.01[a]	84.28±0.04[ab]	84.07±0.01[ab]	82.50±0.02[ab]	81.69±0.01[ab]
Post-harvest – SA 3.0 mM	90.04±0.02[a]	84.70±0.03[ab]	84.19±0.02[ab]	82.68±0.03[ab]	81.78±0.00[ab]
Post-harvest – MeJA/SA 1.5/1.5 mM/mM	90.15±0.00[a]	88.69±0.01[a]	86.24±0.00[a]	85.59±0.01[a]	84.20±0.02[a]

Figures are the mean of three replications; Figures in a row followed by the same letter/s are not differed significantly (α = P=0.05) other findings in different literatures. MeJA significantly enhanced the anthocyanin content in apple (6). SA preharvest treatment increased total flavonoid content in orange (87). There was a significant improvement of flavonoid content on bayberry by MeJA (96) and turnip by SA treatment (97). Low SA dose accelerated the antioxidant capacity and adaptation to abiotic tension, but over SA load resulted in abiotic strain vulnerable to tissue damage (98). SA treatment increased flavonoid content in tea (99-100). 0.5 mM SA treatment significantly improved the total flavonoid content (95). SA treatment was beneficial to improve the total flavonoid content in mandarin fruit (89). The postharvest treatment of MeJA (1 mM) and SA (2 mM) resulted in the highest retention of the phytochemical components in mandarin fruit for 60 days of cold storage (17).

Conclusion

Cantaloupe (*Cucumis melo*) fruit contains a great amount of minerals, antioxidants and micronutrients beneficial for human health. MeJA and SA were widely applied in crop science both at the pre-harvest control diseases and postharvest stages to maintain quality attributes of fruits and vegetables. We have successfully investigated the application of MeJA and SA in individual or combination during spraying at the pre-harvest and dipping at the post-harvest stages of cantaloupe fruit. Findings of our results revealed that there was no significant difference of quality attributes on either pre-harvest or post-harvest treatments by MeJA and SA. MeJA in combination with SA in half treatment dosage created a significant synergistic influence on almost quality properties superior to either MeJA or SA in full treatment dosage.

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Compliance with ethical standards

Conflict of interest: The author strongly confirmed that this research was conducted with no conflict of interest.

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References

1. Turner JG, Ellis C, Devoto A. The jasmonate signal pathway. Plant Cell. 2002; 14(suppl.): 153–64. https://doi.org/10.1105/tpc.000679
2. Heredia JB, Cisneros-Zevallos L. The effect of exogenous ethylene and methyl jasmonate on pal activity, phenolic profiles and antioxidant capacity of carrot (*Daucus carota*) under different wounding intensities. Postharvest Biology Technology. 2009; 51: 242–49. https://doi.org/10.1016/j.postharvbio.2008.07.001.
3. Hamideh M, Zahra P, Vahidreza S. Role of methyl jasmonate and salicylic acid applications on bloom delay, flowering and fruiting of 'Elberta' peach. International Journal of Horticultural Science and Technology. 2015;2(1):75-85.
4. Rohwer CL, Erwin JE. Horticultural applications of jasmonates: A review. Journal of Horticultural Science and Biotechnology. 2008;83(3):283–304.
5. Gonzalez-Aguilar GA, Fortiz J, Cruz R, Baez R, Wang CY. Methyl jasmonate reduces chilling injury and maintains postharvest quality of mango fruit. Journal Agriculture Food Chemistry. 2000; 48:515–19. https://doi.org/10.1021/jf9902806
6. Rudell DR, Mattheis JP, Fan X, Fellman JK. Methyl jasmonate enhances anthocyanin accumulation and modifies production of phenolics and pigments in Fuji'apples. Journal of American Society Horticulture Science. 2002; 127:435–41. http://dx.doi.org/10.21273/JASHS.127.3.435
7. Gonzalez-Aguilar GA, Buta JG, Wang CY. Methyl jasmonate and modified atmosphere packaging (MAP) reduce decay and maintain post harvest quality of papaya 'Sunrise'. Postharvest Biology Technology. 2003;28:361–70. https://doi.org/10.1016/S0925-5214(02)00200-4
8. Yao HJ, Tian SP. Effects of pre- and post-harvest application of salicylic acid or methyl jasmonates on inducing disease resistance of sweet cherry fruit in storage. Postharvest Biology Technology. 2005;35:253–62. https://doi.org/10.1016/j. postharvbio.2004.09.001.
9. Wang SY, Bowman L, Ding M. Methyl jasmonate enhances antioxidant activity and flavonoid content in blackberries (*Rubus* sp.) and promotes antiproliferation of human cancer cells. Food Chemistry. 2008;107:1261–69. https://doi.org/10.1016/j.foodchem.2007.09.065
10. Wang K, Jin P, Cao S, Shang H, Yang Z, Zheng Y. Methyl jasmonate reduces decay and enhances antioxidant capacity in chinese bayberries. Journal of Agriculture and Food Chemistry. 2009;57:5809–15. https://doi.org/10.1021/jf900914a.
11. Jin P, Wang K, Shang H, Tong J, Zheng Y. Low temperature conditioning combined with methyl jasmonate treatment reduces chilling injury of peach fruit. Journal of Science Food Agriculture. 2009;89:1690–96. https://doi.org/10.1002/jsfa.3642
12. Meng X, Han J, Wang Q, Tian SP. Changes in physiology and quality of peach fruits treated by methyl jasmonate under low temperature stress. Food Chemistry. 2009;114:1028–35. https://doi.org/10.1016/j.foodchem.2008.09.109
13. Sayyari M, Babalar M, Kalantari S, Martinez-Romero D, Guillen F, Serrano M, Valero D. Vapor treatments with methyl salicylate or methyl jasmonate alleviated chilling injury and enhanced antioxidant potential during postharvest storage of pomegranates. Food Chemistry. 2011; 124:964–70. http://dx.doi.org/10.1016/j.foodchem.2010.07.036.
14. Flores G, Ruiz Del Castillo ML. Influence of pre-harvest and postharvest methyl jasmonate treatments on flavonoid content and metabolomic enzymes in red raspberry. Postharvest Biology Technology. 2014;97:77–82. https://doi.org/10.1016/j. postharvbio.2014.06.009.
15. Ashgari M, Hasanlooe AR. Interaction effects of salicylic acid and methyl jasmonate on total antioxidant content, catalse and peroxidase enzymes activity in "Sabrosa" strawberry fruit during storage. Science Horticulture. 2015;197:490–95. https://doi.org/10.1016/j.scienta.2015.10.009.
16. Ni J, Zhao Y, Tao R, Yin L, Gao L, Strid A, Qian M, Li J, Li Y, Shen J. Ethylene mediates the branching of the jasmonate-induced flavonoid biosynthesis pathway by suppressing anthocyanin biosynthesis in red Chinese pear fruits. Plant Biotechnology Journal. 2020;18:1223–40. https://doi.org/10.1111/pbi.13287
17. Baswal AK, Dhaliwal HS, Singh Z, Mahajanc BVC. Post-harvest application of methyl jasmonate, 1- methylcyclopropene and salicylic acid elevates health-promoting compounds in cold-stored 'kinnow' mandarin (Citrus *nobilis* Lour x *C. deliciosa* Tenora) fruit. International Journal of Fruit Science. 2021;21(1):147–57. https://doi.org/10.1080/15538362.2020.1860865

18. Babalar M, Asghari M, Talaei A, Khosroshahi A. Effect of pre- and postharvest salicylic acid treatment on ethylene production, fungal decay and overall quality of Selva strawberry fruit. Food Chemistry. 2007;105:449-53. https://doi.org/10.1016/j.foodchem.2007.03.021

19. Asghari M, Aghdam MS. Impact of salicylic acid on post-harvest physiology of horticultural crops. Trends in Food Science Technology. 2010;21:502–09. https://doi.org/10.1016/j.tifs.2010.07.009

20. Morris K, MacKerness SA, Page T, John CF, Murphy AM, Carr JP. Salicylic acid has a role in regulating gene expression during leaf senescence. Plant Journal. 2000;23:677–85. https://doi.org/10.1046/j.1365-313x.2000.00836.x

21. Martinez C, Pons E, Prats G, Leon J. Salicylic acid regulates flowering time and links defence responses and reproductive development. Plant Journal. 2004;37:209–17. https://doi.org/10.1046/j.1365-313X.2003.01954.x

22. Xie Z, Zhang ZL, Hanzlik S, Cook E, Shen QJ. Salicylic acid inhibits gibberellin-induced alpha-amylase expression and seed germination via a pathway involving an abscisic-acid-inducible WRKY gene. Plant Molecule Biology. 2007;64:293–303. https://doi.org/10.1007/s11103-007-9152-0

23. Quiroga G, Erice G, Aroca R, Zamarreno AM, Garcia-Mina JM, Ruiz-Lozano JM. *Arbuscular mycorrhizal* symbiosis and salicylic acid regulate aquaporins and root hydraulic properties in maize plants subjected to drought. Agriculture Water Management. 2018;202:271–84. https://doi.org/10.1016/j.agwat.2017.12.012

24. Larkindale J, Knight MR. Protection against heat stress-induced oxidative damage in arabidopsis involves calcium, abscisic acid, ethylene and salicylic acid. Plant Physiology. 2002;128:682–95. https://doi.org/10.1104/pp.010320

25. Songul Canakci S, Dursun B. The effect of pre-application of salicylic acid on some physiological and biochemical characteristics of tomato seedling (*Lycopersicon esculentum* L.) growing in cadmium containing media. African Journal of Biotechnology. 2012;11:3173–78. https://doi.org/10.5897/AJB 11.2364

26. Gharbi E, Lutts S, Dailly H, Quinet M. Comparison between the impacts of two different modes of salicylic acid application on tomato (*Solanum lycopersicum*) responses to salinity. Plant Signaling and Behavior. 2018;13:e1469361. https://doi.org/10.1080/15592324.2018.1469361

27. Shin H, Min K, Arora R. Exogenous salicylic acid improves freezing tolerance of spinach (*Spinacia oleracea* L.) leaves. Cryobiology. 2018;81:192–200. https://doi.org/10.1016/j.cryobiol.2017.10.006

28. Chen C, Zheng J, Wan C, Chen M, Chen J. Effect of carboxymethyl cellulose coating enriched with clove oil on postharvest quality of 'Xinyu' mandarin oranges. Fruits. 2016;71:319–27. https://doi.org/10.1051/fruits/2016019.

29. Srivastava MK, Dwivedi UN. Delayed ripening of banana fruit by salicylic acid. Plant Science. 2000; 158:87–96. https://doi.org/10.1016/S0168-9452(00)00304-6

30. Fung RWM, Wang CY, Smith DL, Gross KC, Tian M. MeSA, MeJA increase steady-state transcript levels of alternative oxidase and resistance against chilling injury in sweet peppers (*Capsicum annuum* L.). Plant Science. 2004;166:711–19. https://doi.org/10.1016/j.plantsci.2003.11.009

31. Khademi Z, Ershadi A. Postharvest application of salicylic acid improves storability of peach (*Prunus persica* cv. Elberta) fruits. International Journal of Agriculture and Crop Science. 2013; 5:651–55.

32. Davarynejad GH, Zarei M, Nasrabadi ME, Ardakani E. Effects of salicylic acid and putrescine on storability, quality attributes and antioxidant activity of plum cv. 'Santa Rosa. Journal of Food Science and Technology. 2015;52:2053–62. https://doi.org/10.1007/s13197-013-1232-3.

33. Amanullah S, Sajid M, Qamar MB, Ahmad S. Postharvest treatment of salicylic acid on guava to enhance the shelf life at ambient temperature. International Journal Bioscience. 2017;10:92–106. http://dx.doi.org/10.12692/ijb/10.3.92-106

34. Mustafa MA, Ali A, Seymour G, Tucker G. Delayed pericarp hardening of cold stored mangosteen (*Garcinia mangostana* L.) upon pretreatment with the stress hormones methyl jasmonate and salicylic acid. Science Horticulture. 2018;230:107–16. https://doi.org/10.1016/j.scienta.2017.11.017

35. Haider ST, Ahmad S, Khan AS, Anjum MA, Nasir M, Naz S. Effect of salicylic acid on postharvest quality of "Kinnow" mandarin under cold storage. Science Horticulture. 2020;259:108843. https://doi.org/10.1016/j.scienta.2019.108843.

36. Leslie CA, Romani RJ. Inhibition of ethylene biosynthesis by salicylic acid. Plant Physiology. 1988;88:833–37. https://doi.org/10.1104/pp.88.3.833

37. Zhu CQ, Hu WJ, Cao XC, Zhu LF, Bai ZG, Huang J. Role of salicylic acid in alleviating the inhibition of root elongation by suppressing ethylene emission in rice under Al toxicity conditions. Plant Growth Regulation. 2020;90:475–87. https://doi.org/10.1007/s10725-019-00554-7

38. Miura K,Tada Y. Regulation of water, salinity and cold stress responses by salicylic acid. Frontiers in Plant Science. 2014;5:4. https://doi.org/10.3389/fpls.2014.00004

39. Sangamithra A, Ragavi P. Post-harvest attributes of muskmelon (*Cucumis melo*): a mini review on the potential of value addition. Current Nutrition and Food Science. 2020;16(6):854-59. https://doi.org/10.2174/1573401315666191113154843

40. Ahmad D, Muhammad N, Farhan S, Muhammad HA, Tabussam T, Huma BUA, Zarina M, Shahzad H, Faqir MA. Development and optimization of processing techniques for intermediate moisture muskmelon chunks. Food Science and Nutrition. 2019;7(10):3253-60. https://doi.org/10.1002/fsn3.1183

41. Raji MR, Lotfi M, Tohidfar M, Zahedi B, Carra A, Abbate L, Carimi F. Somatic embryogenesis of muskmelon (*Cucumis melo* L.) and genetic stability assessment of regenerants using flow cytometry and ISSR markers. Protoplasma. 2018; 255(3):873–83. https://doi.org/10.1007/s00709-017-1194-9

42. Mallek-Ayadi S, Bahloul N, Kechaou N. Characterization; phenolic compounds and functional properties of *Cucumis melo* L. peels. Food Chemistry. 2017;221:1691–97. https://doi.org/10.1016/j.foodchem.2016.10.117

43. Fundo JF, Miller FA, Garcia E, Santos JR, Silva CL, Brandao TR. Physicochemical characteristics, bioactive compounds and antioxidant activity in juice, pulp, peel and seeds of Cantaloupe melon. Journal of Food Measurement Characteristics. 2018;12:292–300. https://doi.org/10.1007/s11694-017-9640-0

44. Nguyen PM. Combination of chitosan and lemongrass (*Cymbopogon citratus*) essential oil as edible coating to cantaloupe (*Cucumis melo* L) quality and shelf life during storage. Journal of Global Pharma Technology. 2018;11:22-24.

45. Filomena MV, Domenico C, Bruna L. Characterization of polyphenolic compounds in cantaloupe melon by-products. Foods. 2019;8:1-10. https://doi.org/10.3390/foods8060196

46. Vouldoukis I, Lacan D, Kamate C, Coste P, Calenda A, Mazier D, Conti M, Dugas B. Antioxidant and anti-inflammatory properties of a *Cucumis melo* LC. extract rich in superoxide dismutase activity. Journal of Ethnopharmacology. 2004;94:67–75. https://doi.org/10.1016/j.jep.2004.04.023

47. Ismail HI, Chan KW, Mariod AA, Ismail M. Phenolic content and antioxidant activity of cantaloupe (*Cucumis melo*) methanolic extracts. Food Chemistry. 2010;119:643–47. https://doi.org/10.1016/j.foodchem.2009.07.023

48. Milind P, Kulwant S. Muskmelon is eat-must melon. International Research Journal of Pharmaceutical. 2011;2:52–57.

49. Shirin MG, Harmit S, Mendel F. Phenolic content and antioxidant activity of extracts of 12 melon (*Cucumis melo*) peel powders prepared from commercial melons. Journal of Food Science. 2019;84:1943-48. https://doi.org/10.1111/1750-3841.14666

50. Mayberry KS, Hartz TK. Extension of muskmelon storage through the use of hot water life treatment and polyethylene wraps. Hortscience. 1992;27(4):324-26.

51. Zainal Abidin M, Shamsudin R, Othman Z, Abdul Rahman R. Effect of postharvest storage of whole fruit on physico-chemical and microbial changes of fresh-cut cantaloupe (*Cucumis melo* L. *reticulatus* cv. Glamour). International Food Research Journal. 2013;20(1):953-60. http://ifrj.upm.edu.my/20%20(02)%202013/62%20IFRJ%2020%20(02)%202013%20Rosnah%20(238).pdf

52. Yuan L, Bi Y, Ge Y, Wang Y, Li G. Postharvest hot water dipping reduce decay by inducing disease resistance and maintaining firmness in muskmelon (*Cucumic melon.)* fruit. Scientia Horticulturae. 2013;161(3):101-10. http://dx.doi.org/10.1016/j.scienta.2013.06.041

53. Edna MMA, Jeane MMA, Glauber HSN, Maria ZN, Cristiane AP, Marcelo SS. Cantaloupe melon (*Cucumis melo* L.) conservation using hydrocooling. Revista Ceres. 2016;63(2):191-97. https://doi.org/10.1590/0034-737X201663020010

54. Suriyan S, Gregory, Tucker A. The effect of 1-Methylcyclopropene (1-MCP) on quality and cell wall hydrolases activities of fresh-cut muskmelon (*Cucumis melo* var reticulatus L.) during storage. Food Bioprocess Technology. 2013;6:2196–2201. https://doi.org/10.1007/s11947-011-0776-3

55. Azam MM, Eissa AHA, Hassan AH. Monitoring of change in cantaloupe fruit quality under pre-cooling and storage treatments. Journal of Food Processing and Technology. 2015,6:12. https://doi.org/10.4172/2157-7110.1000527

56. Nguyen PM. Effect of 1-Methylcyclopropene on antioxidants of cantaloupe (*Cucumis melo*) fruit during storage. Research on Crops. 2020;21(1):185-89. http://dx.doi.org/10.31830/2348-7542.2020.031

57. Nizar S, Elhadi MM, Algaili MA, Hozeifa MH, Mohamed O. Determination of total phenolic content and antioxidant activity of roselle (*Hibiscus sabdariffa* L.) calyx ethanolic extract. Standard Research Journal of Pharmacy and Pharmacology. 2014;1:034-39.

58. Formagio ASN, Ramos DD, Vieira MC, Ramalho SR, Silva MM, Zárate NAH, Foglio MA, Carvalho JE. Phenolic compounds of *Hibiscus sabdariffa* and influence of organic residues on its antioxidant and antitumoral properties. Brazilian Journal of Biology. 2015;75:69-76. https://doi.org/10.1590/1519-6984.07413

59. Martinez-Ferrar M, Harper C. Reduction in microbial growth and improvement of the storage quality in fresh-cut pineapple after methyl jasmonate treatment. Journal of Food Quality. 2005;28:3–12. http://dx.doi.org/10.1111/j.1745-4557.2005.00007.x

60. Wang L, Chen S, Kong W, Li S, Archbold D. Salicylic acid pretreatment alleviates chilling injury and affects the antioxidant system and heat shock proteins of peaches during cold storage. Postharvest Biology Technology. 2006;41:244–51. https://doi.org/10.1016/j.postharvbio.2006.04.010

61. Shafiee M, Taghavi TS, Babalar M. Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid, and calcium dipping) improved postharvest fruit quality of strawberry. Science Horticulture. 2010;124:40–45. https://doi.org/10.1016/j.scienta.2009.12.004

62. Valero D, Diaz-Mula HM, Zapata PJ, Castillo S, Guillen F, Martinez-Romero D, Serrano M. Postharvest treatments with salicylic acid, acetylsalicylic acid or oxalic acid delayed ripening and enhanced bioactive compounds and antioxidant capacity in sweet cherry. Journal of Agriculture Food Chemistry. 2011;59:5483–89. https://doi.org/10.1021/jf200873j

63. Satraj A, Masud T, Abbasi KS, Mahmood T, Ali A. Effect of different concentrations of salicylic acid on keeping quality of apricot cv. 'Habi' at ambient storage. Journal of Biological Food Science Research. 2013;2:66–78.

64. Jin P, Zheng YH, Cheng CM, Gao HY, Chen WX, Chen HJ. Effect of methyl jasmonate treatment on fruit decay and quality in peaches during storage at ambient temperature. Acta Horticulture. 2006;712:711–16. https://doi.org/10.17660/ActaHortic.2006.712.90

65. Ezzat A, Ammar A, Szabo Z, Nyeki J, Holb IJ. Postharvest treatments with methyl jasmonate and salicylic acid for maintaining physico-chemical characteristics and sensory quality properties of apricot fruit during cold storage and shelf-life. Polish Journal of Food Nutrition Science. 2017;67:159–66. http://dx.doi.org/10.1515/pjfns.2016.0013.

66. El-Mogy MM, Ali MR, Darwish OS, Rogers HJ. Impact of salicylic acid, abscisic acid and methyl jasmonate on postharvest quality and bioactive compounds of cultivated strawberry fruit. Journal of Berry Research. 2019;9:333–48. http://dx.doi.org/10.3233/JBR-180349

67. Changwal C, Shukla T, Hussain Z, Singh N, Kar A, Singh VP, Abdin MZ, Arora A. Regulation of Post harvest Tomato Fruit Ripening by Endogenous Salicylic Acid. Frontiers Plant Science. 2021;12:663943. https://doi.org/10.3389/fpls.2021.663943

68. Zheng Y, Zhang Q. Effects of polyamines and salicylic acid postharvest storage of 'Ponkan' mandarin. Acta Horticulture. 2004;632:317–20. https://doi.org/10.17660/ActaHortic.2004.632.41

69. Dar TA, Uddin M, Khan MMA, Hakeem KR, Jaleel H. Jasmonates counter plant stress: A review. Environmental and Experimental Botany. 2015;115:49-57. https://doi.org/10.1016/j.envexpbot.2015.02.010

70. Moline HE, Buta JG, Maas JL, Saftner RA. Comparison of three volatile natural products for the reduction of postharvest decay in strawberries. Advances in Strawberry Research. 1997;16:13–18. http://dx.doi.org/10.2212/spr.2010.4.1

71. Buta JG, Moline HE. Methyl jasmonate extends shelf life and reduces microbial contamination of fresh-cut celery and peppers. Journal of Agricultural and Food Chemistry. 1998;46:1253–56. https://doi.org/10.1021/jf9707492

72. Droby S, Porat R, Cohen L, Weiss B, Shapiro B, Philosoph-Hadas S, Meir S. Suppressing green mold decay in grapefruit with postharvest jasmonate application. Journal of the American Society for Horticultural Science. 1999;124:184–88. http://dx.doi.org/10.21273/JASHS.124.2.184

73. Wang CY. Maintaining postharvest quality of raspberries with natural volatile compounds. International Journal of Food Science and Technology. 2003;38:869–75. https://doi.org/10.1046/j.0950-5423.2003.00758.x

74. Darras AI, Terry LA, Joyce DC. Methyl jasmonate vapour treatment suppresses specking caused by *Botrytis cinerea* on *Freesia hybrida* L. flowers. Postharvest Biology and Technology. 2005;38:175–82. https://doi.org/10.1016/j.postharvbio.2005.06.011

75. Ayala-Zavala JF, Wang SY, Wang CY, Gonzalez-Aguilar GA. Methyl jasmonate in conjunction with ethanol treatment increases antioxidant capacity, volatile compounds and postharvest life of strawberry fruit. European Food Research Technology. 2005;221:731–38. https://doi.org/10.1007/s00217-005-0069-z

76. Krishna H, Das B, Attri BL, Kumar A, Ahmed N. Interaction between different pre- and postharvest treatments on shelf life extension of 'Oregon Spur' apple. Fruits. 2012;67(1):31 – 40. https://doi.org/10.1051/fruits/2011064

77. Zhang FS, Wang XQ, Ma SJ, Cao SF, Li N, Wang XX, Zheng YH.

Effects of methyl jasmonate on postharvest decay in strawberry fruit and the possible mechanisms involved. Acta Horticulture. 2006;712:693-98. https://doi.org/10.17660/ActaHortic.2006.712.87

78. Saavedra GM, Figueroa NE, Poblete LA, Cherian S, Figueroa CR. Effects of preharvest applications of methyl jasmonate and chitosan on postharvest decay, quality and chemical attributes of *Fragaria chiloensis* fruit. Food Chemistry. 2016;190:448-53. http://dx.doi.org/10.1016/j.foodchem.2015.05.107

79. Saavedra GM, Sanfuentes E, Figueroa PM, Figueroa CR. Independent preharvest applications of methyl jasmonate and chitosan elicit differential upregulation of defense-related genes with reduced incidence of gray mold decay during postharvest storage of fragaria chiloensis fruit. International Journal of Molecular Sciences. 2017;18(7):1420. http://dx.doi.org/10.3390/ijms18071420

80. Quiroz-Lopez EP, Renteria-Martinez ME, Ramirez-Bustos II, Moreno-Salazar SF, Martinez-Ruiz FE, Villar-Luna E, Fernandez-Herrera E. Effect of salicylic acid and methyl jasmonate on *Colletotrichum* sp. in mango fruits. Tropical and Subtropical Agroecosystems. 2021;24:44. http://www.revista.ccba.uady.mx/urn:ISSN:1870-0462-tsaes.v24i2.34949

81. Hubbard NL, Pharr DM, Huber SC. Sucrose phosphate synthase and other sucrose metabolizing enzymes in fruits of various species. Physiology Plant. 1991;82:191–96. https://doi.org/10.1111/j.1399-3054.1991.tb00080.x

82. Aghdam MS, Mostofi Y, Motallebiazar A, Ghasemneghad M, Fattahi MJ. Methyl salicylate affects the quality of 'Hayward' kiwifruits during storage at low temperature. Journal of Agriculture Science. 2011;3149–56. https://doi.org/10.5539/jas.v3n2p149

83. Aghdam MS, Asghari M, Khorsandi O, Mohayeji M. Alleviation of postharvest chilling injury of tomato fruit by salicylic acid treatment. Journal of Food Science Technology. 2012;51:2815–20. https://doi.org/10.1007/s13197-012- 0757-1

84. Habibi F, Ramenzanian A, Guillen F, Serrano M, Valero D. Blood oranges maintain bioactive compounds and nutritional quality by postharvest treatments with γ-aminobutyric acid, methyl jasmonate or methyl salicylate during cold storage. Food Chemistry. 2020;306:125634. https://doi.org/10.1016/j.foodchem.2019.125634.

85. Perez AG, Sanz C, Richardson DG, Olias JM. Methyl jasmonate vapor promotes β-carotene synthesis and chlorophyll degradation in golden delicious apple peel. Journal of Plant Growth Regulation. 1993;12:163. https://doi.org/10.1007/BF00189648

86. Fan X, Mattheis JP, Fellman JK. A role for jasmonates in climacteric fruit ripening. Planta. 1998;204:444–49. https://doi.org/10.1007/s004250050278

87. Huang R, Xia R, Lu Y, Hu L, Xu Y. Effect of pre-harvest salicylic acid spray treatment on post-harvest antioxidant in the pulp and peel of 'Cara cara' navel orange (*Citrus sinenisis* L. Osbeck). Journal of Science Food and Agriculture. 2008;88:229–36. https://doi.org/10.1002/jsfa.3076

88. Liu L, Wei J, Zhang M, Zhang L, Li C, Wang Q. Ethylene independent induction of lycopene biosynthesis in tomato fruits by jasmonates. Journal of Experimental Botany. 2012;63:5751–61. https://doi.org/10.1093/jxb/ers224

89. Yamamoto R, Ma G, Zhang L, Hirai M, Yahata M, Yamawaki K, Shimada T, Fujii H, Endo T, Kato M. Effects of salicylic acid and methyl jasmonate treatments on flavonoid and carotenoid accumulation in the juice sacs of satsuma mandarin *in vitro*. Applied Science. 2020;10:8916. https://doi.org/10.3390/app10248916

90. Li L, Van Staden J, Jager AK. Effects of plant growth regulators on the antioxidant system in seedlings of two maize cultivars subjected to water stress. Plant Growth Regulation. 1998;25:81–87. https://doi.org/10.1023/A:1010774725695

91. Wang CY. Methyl jasmonate reduces water stress in strawberry. Journal of Plant Growth Regulation. 1999;18:127–34. https://doi.org/10.1007/pl00007060

92. Wolucka BA, Goossens A, Inze D. Methyl jasmonate stimulates the de novo biosynthesis of vitamin C in plant cell suspensions. Journal of Experimental Botany. 2005;56:2527–38. https://doi.org/10.1093/jxb/eri246

93. Lolaei A, Zamani S, Ahmadian E, Mobasheri S. Effect of methyl jasmonate on the composition of yield and growth of strawberry (Selva and Queen Elisa). International Journal of Agriculture Crop Science. 2013;5:200-06.

94. Wang SY, Zheng W. Preharvest application of methyl jasmonate increases fruit quality and antioxidant capacity in raspberries. International Journal of Food Science and Technology. 2005;40:187–95. https://doi.org/10.1111/j.1365-2621.2004.00930.x

95. Preciado-Rangel P, Reyes-Perez JJ, Ramerez-Rodriguez SC, Salas-Perez L, Fortis-Hernandez M, Murillo-Amador B, Troyo-Dieguez E. Foliar aspersion of salicylic acid improves phenolic and flavonoid compounds and also the fruit yield in cucumber (*Cucumis sativus* L.). Plants. 2019;8:44. https://dx.doi.org/10.3390%2Fplants8020044

96. Sangpyayoon P, Supapvanich S, Youryon P, Wongs-Aree C, Boonyaritthongchai P. Efficiency of salicylic acid or methyl jasmonate immersions on internal browning alleviation and physico-chemical quality of Queen pineapple cv. ''Sawi" fruit during cold storage. Journal of Food Biochemistry. 2019;13059:1–11. http://dx.doi.org/10.1111/jfbc.13059.

97. Thiruvengadam M, Baskar V, Kim S, Chung S. Effects of abscisic acid, jasmonic acid and salicylic acid on the content of phytochemicals and their gene expression profiles and biological activity in turnip (*Brassica rapa* ssp. *rapa*). Plant Growth Regulation. 2016;80:377–90. https://doi.org/10.1007/s10725-016-0178-7.

98. Hara M, Furukawa J, Sato A, Mizoguchi T, Miura K. Abiotic stress and role of salicylic acid in plants. In abiotic stress responses in plants (Springer). 2012;235–51. https://link.springer.com/chapter/10. 1007%2F978-1-4614-0634-1_13

99. Martinez-Espla A, Zapata PJ, Valero D, Martinez-Romero D, Diaz-Mula HM, Serrano M. Preharvest treatments with salicylates enhance nutrient and antioxidant compounds in plum at harvest and after storage. Journal of Science Food and Agriculture. 2018;98:2742–50. https://doi.org/10.1002/jsfa.8770

100. Li X, Zhang LP, Zhang L, Yan P, Ahammed GJ, Han WY. Methyl salicylate enhances flavonoid biosynthesis in tea leaves by stimulating the phenylpropanoid pathway. Molecules. 2019;24:362. https://doi.org/10.3390/molecules24020362

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