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Effects of 1-Methylcyclopropane, Activated Carbon and Potassium Permanganate on Quality of Cantaloupe Fruits and Snap Beans During Mixed Load

[1]Sheren A. Atala and [2]El-Gendy Manal A.

[1]Department of Postharvest and Handling of Vegetable Crops,
Horticulture Research Institute, Agricultural Research Center, Giza, Egypt
[2]Food Technology Research Institute, Agricultural Research Center, Giza, Egypt

Abstract: This study was carried out on cantaloupe fruits (*Cucumis melo* L.) cv. Primal Galia type; were harvested at light yellow with green coloring stage and snap bean pods (*Phaseolus vulgaris* L.) cv. Hama were harvested in the proper stage of marketing in 2019 and 2020 seasons from a private farm at Fayed district, Ismailia Governorate. Fruits and pods were transferred to the laboratory of Vegetable Handling Research Department, Horticultural Research Institute, Agricultural Research Center at Giza to study the effect of 1-MCP as sheet contained 5%, activated carbon sachets (5 or 10g) and potassium permanganate sachets (2.5 or 5g) inserted in sealed polypropylene film on quality and storability in mixed load of cantaloupe fruits and snap bean pods during storage at 5°C and 90-95 % RH for 20 days. Results indicated that cantaloupe fruits and snap bean pods packed with 1-MCP at 5% or activated carbon at 5g were the most effective treatments in reducing weight loss percentage, color change and maintaining general appearance of fruits and pods, firmness, total soluble solids and ascorbic acid content during storage. The gas composition inside the package treated with 1-MCP treatment had high O_2 % and low CO_2 % and lower accumulation of ethylene, as ethylene is removed, the process of ripening can be slowed dramatically prolong the storage life of produce. Mixed load of cantaloupe fruits and snap bean pods packed with 1-MCP at 5% treatment showed the best appearance and maintaining postharvest quality, cantaloupe fruits did not exhibit any changes in general appearance till the end of storage (20 days), while snap bean pods showed good appearance at the same period. However, activated carbon (5 or 10g) gave good appearance in cantaloupe fruits after 20 days of storage, while snap bean pods gave good appearance after 16 days of storage.

Key words: Mixed loads · 1-MCP · Activated carbon · Potassium permanganate · Cantaloupe · Snap bean · Storability

INTRODUCTION

Cantaloupes are typical climacteric fruits that exhibit characteristics rise in ethylene production and respiration rate during ripening [1]. Ethylene is usually associated with short shelf life, soft texture, color change, accelerating the natural processes of development, ripening and senescence [2].

Snap beans are categorized as a highly perishable vegetable and sensitive of ethylene [3]. Snap beans exposure to low levels of ethylene can promote yellowing and shorten the storage life.

Fresh fruits and vegetables have various requirements for temperature, humidity and have varying sensitivity to ethylene induced damage from other produce [4]. The quality of fruit sensitive to ethylene may be affected due to exogenous ethylene produced by other commodities so, mixed load products such as cantaloupe, pears, apples and bananas which produce ethylene with products such as Lettuce, broccoli and snap bean which sensitive to ethylene were deteriorate rapidly [5].

Ella *et al.* [6] showed that the high level of ethylene emitted led to postharvest damage to other mixed-load fresh products which are sensitive to the hormone but are not protected against it.

Ethylene has been known to play a pivotal role in accelerating ripening and senescence in fresh produce [7]. The benefits of reducing ethylene levels in slowing down

Corresponding Author: Sheren A. Atala, Department of Postharvest and Handling of Vegetable Crops, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.

ripening and senescence and increase in shelf life of some climacteric and non-climacteric horticultural commodities have been widely studied [8-10]. Therefore, ethylene management is great importance along the supply chain.

To delay ripening of cantaloupe and maintaining quality of snap bean during mixed load, it is necessary to use technologies that reduce or remove the ethylene of the storage environment and this can be achieved by using products such as 1-MCP or activated carbon or potassium permanganate.

1-methylcyclopropene point out to potential benefits of crops during storage. Its important play in delaying ripening or senescence processes is a gaseous substance which averts ethylene binding to active sites causing delay in formation of color, firmness and ethylene production in tomato fruit [11-15].

1-methylcyclopropene can be used as ethylene binding inhibitors in order to extend storage of tomato and pepper fruit [13, 16].

Ibrahim and Abdullah [17] found that 1-MCP treatment delaying ripening and extend the shelf life of tomato fruits and maintaining the fruit quality of sweet pepper when stored together (mixed load) at 10°C for 21 days.

Activated carbon is the main compound used as ethylene adsorber, thus delaying ripening and maintaining fruit quality during storage [18]. Avani *et al.* [19] revealed that activated charcoal was the most effective, cheaply available and easily applicable method for delaying fruit ripening and senescence in fruits crops and are also found to be effective in control of decay loss.

Bailen *et al.* [20] reported that tomato fruits packed in non-perforated oriental polypropylene bags containing granular-activated carbon (GAC) led to the lower ethylene accumulation inside packages, while the higher was obtained in controls. Thus, a reduction in color, softening, weight loss and decay of tomato fruit and received the higher scores in terms of sweetness, firmness, juiciness, color, odor and flavor compared to untreated control during storage.

Potassium permanganate ($KMnO_4$) is a stable purple solid that is a strong oxihzing agent and reahly oxihzes ethylene [21]. Postharvest application with $KMnO_4$ as an ethylene absorbent, delayed fruit ripening proved most effective in reducing rot and maintained the physical appearance and quality of banana and tomato fruits in fresh conditions [22-24].

Thus, the present investigation aims to extend the storage period of cantaloupe fruits mixed load with snap beans by environmentally safe of 1-Methylcyclopropene, activated carbon and potassium permanganate. Also, the effect of those treatments on the cantaloupe fruits and snap beans quality during different storage period was investigated and compared to control fruit.

MATERIALS AND METHODS

Cantaloupe fruits (*Cucumis melo* L.) cv. Primal Galia type; were harvested at light yellow with green coloring stage (color stage 3) according to Fallik *et al.* [25] and snap beans pods (*Phaseolus vulgaris* L.) cv. Hama were harvested in the proper stage of marketing in 2019 and 2020 seasons from a private farm at Fayed district, Ismailia Governorate . Fruits and pods were harvested on February 20 and 24 in 2019 and 2020 seasons, respectively and were transferred to the laboratory of Vegetable Handling Research Department, Horticultural Research Institute, Agricultural Research Center and were kept overnight at 5°C and 90-95 % relative humidity (RH).

In the following day, uniform fruits and pods in color, size, appearance, with no physical defects or fungal infection were selected and placed in the same carton box (33 cm x 23 cm x 12.5 cm) contained three cantaloupe fruits and three trays of snap bean pods and each tray was approximately 250g, each box represented as one experimental unit (Eu) randomly distributed into six groups as follows:

T_1: 1-Methylcyclopropane sheets contained 5% per box.
T_2: Activated carbon micro-perforated sachets (3.5 × 4 cm) contained 5g per box.
T_3: Activated carbon micro-perforated sachets (3.5 × 4 cm) contained 10g per box.
T_4: Potassium permanganate sachets contained 2.5g per box.
T_5: Potassium permanganate sachets contained 5g per box.
T_6: Untreated control.

$KmnO_4$ encased in small polyethylene bags perforated only on one side of box to avoid staining the fruits.

Samples of all treatments were tightly overwrapped with polypropylene film (30µm thickness) and were arranged in complete randomized design. The samples were stored at 5°C and 90-95 % relative humidity (RH) for 20 days and were taken at random from the three experimental units (Eu) and examined every 0, 4, 8, 12, 16 and 20 days at 5°C.

For the changes in the quality parameters during storage as follows:

- Loss in weight percentage calculated by the following equation: Loss in weight % = Initial weight of head – weight of head at sampling date / the initial weight of the head ×100.
- The general appearance: as evaluated using a scale from 9 to 1, where 9= excellent, 7= good, 5= fair, 3= poor and 1= unsalable fruits rating (5) or below were considered as unmarketable, as described by Kader *et al*. [26].
- Firmness: cantaloupe fruit firmness was determined at the same two positions on each fruit using a firmness tester, (Pressure Tester) with an 8 mm plunger and snap bean pods firmness as recorded by TA- 1000 texture analyzer instrument using a penetrating cylinder of 1mm diameter, to a constant distance (3 and 5mm) inside the pulp of pods and by a constant speed 2mm per sec.
- External surface color was evaluated by a color meter (Minolta CR 200) to measure the lightness (L value) and b value for cantaloupe fruit and the lightness (L value) and hue angle (h°) value for snap bean pods.
- Total soluble solids percentage (TSS) was determined as a composite juice sample by digital refractometer, "Model Abbe Leica" according to [27].
- Ascorbic acid content (as indicated for vit. C). It was determined by titration method using 2, 6 discloro phenol indophenols as described in [27].

Gas Composition Inside the Packages: Gas composition inside the packages was measured using F-950 Handheld Ethylene Analyzer that measures 3 critical gases: Ethylene, CO_2 and O_2 to maintain optimum produce quality at every phase of handling during storage.

Statistical Analysis: Statistical analysis was performed on the studied traits for each season and pooled analysis was carried out when the errors were homogeneous. The homogeneity of variances for the two seasons was checked by use of Levene [28] test. The combined data across the two seasons of the study were analyzed.

RESULTS AND DISCUSSION

Weight Loss Percentage: Data in Table (1) showed that weight loss percentage of cantaloupe fruits and snap bean pods during mixed load increased considerably and consistently with the prolongation of storage periods. The weight loss is a natural consequence of the catabolism of horticultural products, the loss in weight may be attributes to respiration and other senescence related metabolic processes during storage [29]. Similar results were reported by Haffez [30] on cantaloupe fruits and Shehata *et al.* [31] and Gad El-Rab [32] on snap bean pods.

Concerning the effect of postharvest treatments, data revealed that there were significant differences among treatments in weight loss percentage of cantaloupe fruits and snap bean pods during storage. All postharvest treatments retained their weight during storage as compared with untreated control. Moreover, mixed load of cantaloupe fruits and snap bean pods packed with 1-methylcyclopropane at 5% and activated carbon at 5g were the most effective treatments in reducing the weight loss% with significant differences between them followed by activated carbon at 10g. Potassium permanganate at 5g treatment was less effective in this concern; the control gave the highest values of weight loss. These results were in agreement with Fang *et al.* [33], Ibrahim and Abdullah [17] and Poyesh *et al.* [34] for 1-MCP, Bailen *et al.* [20] for activated carbon and Akbari &Rahemi [35], Haffez [30] and Kostekli *et al.* [24] for potassium permanganate.

Ibrahim and Abdullah [17] found that mixed load of tomatoes and sweet pepper fruits packed with 1-MCP reduced the weight loss % during storage at 10°C.

The reducing of weight loss % of cantaloupe fruits and snap bean pods during storage by using 1-MCP or activated carbon or potassium permanganate treatments may be due to that these materials removes or absorb exogenous ethylene from atmosphere surrounding produce (which produce from cantaloupe fruits), which decreased respiration rate and consequently retarded fresh weight loss [36, 37, 24]. Also, Machado *et al.* [38] for 1-MCP on cantaloupe and Sammi and Masud [39] for potassium permanganate on tomato found that these materials significantly delayed the onset of climacteric ethylene production and respiration rate during storage, which diminished the weight loss in fruit during storage.

In general, the interaction between postharvest treatments and storage periods was significant effect on weight loss percentage during storage. After 20 days of storage, the lowest value of weight loss was recorded from mixed load of cantaloupe fruits and snap bean pods treated with 1-MCP at 5% while the highest ones were obtained from untreated control.

General Appearance (GA): Data in Table (2) show that there was significant reduction in general appearance (score) of cantaloupe fruits and snap bean pods during mixed load with the prolongation of storage period.

Table 1: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on weight loss percentage of cantaloupe fruits and snap bean pods during mixed load

	Cantaloupe fruits						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	0.00 x	0.33 w	0.73 u	0.95 st	1.11 r	1.67 m	0.80 F
T_2	0.00 x	0.63 v	1.02 rs	1.48 n	1.96 k	2.80 h	1.32 E
T_3	0.00 x	0.90 t	1.24 q	1.62 m	2.26 j	3.14 f	1.53 D
T_4	0.00 x	1.10 r	1.36 op	1.94 k	2.48 i	3.71d	1.76 C
T_5	0.00 x	1.31 pq	1.69 lm	2.20 j	3.46 e	4.48 b	2.19 B
T_6	0.00 x	1.44 no	1.79 l	3.01 g	4.09 c	5.26 a	2.60 A
Means	0.00 F	0.95 E	1.31 D	1.87 C	2.56 B	3.51 A	
	Snap bean pods						
	Storage period in days						
Treatments [x]	Start	4	8	12	16	20	Means
T_1	0.00 u	0.19 t	0.24 st	0.34 rs	0.50 pq	0.63 o	0.32 F
T_2	0.00 u	0.44 qr	0.55 o-q	0.76 n	0.99 m	1.42 jk	0.69 E
T_3	0.00 u	0.49 pq	0.76 n	0.97 m	1.30 kl	1.63 h	0.86 D
T_4	0.00 u	0.57 op	1.23 l	1.42 jk	1.87 g	2.30 e	1.23 C
T_5	0.00 u	0.88 mn	1.60 hi	2.01 f	2.47 d	3.90 b	1.81 B
T_6	0.00 u	1.49 ij	1.79 g	2.30 e	3.29 c	5.38 a	2.37 A
Means	0.00 F	0.67 E	1.03 D	1.30 C	1.73 B	2.54 A	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x]T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5: potassium permanganate at 5g, T_6: control

These results were in agreement with those obtained by Atress and Attia, [40] on cantaloupe fruits and Shehata *et al.* [31] and Gad El-Rab, [32] on snap bean pods. The decreases in GA of snap bean pods during storage period might be due to shriveling, wilting, color change and decay [41]. Such decrease in GA of cantaloupe fruits mostly may be due to a slight dryness of the fruit surface, instead of translucency or macroscopic decay, as reported by Atress and Attia [40].

As regards the effect of postharvest treatments, data revealed that there were significant differences between postharvest treatments and untreated control during storage. Cantaloupe fruits and snap bean pods treated with all postharvest treatments had significantly the highest score of appearance as compared with untreated control which recorded the lowest score of GA and deteriorated rapidly. However, mixed load of cantaloupe fruits and snap bean pods packed with 1-methylcyclopropane at 5% or activated carbon at 5g were the most effective treatments for maintaining general appearance with no significant differences between them in cantaloupe fruits followed by activated carbon at 10g. Pods and fruits packed with potassium permanganate at 5g were the less effective treatment in maintaining GA, while untreated control recorded the lowest ones in this concern. These results were in agreement with those reported by Budu and Joyce [42], Machado *et al.* [38] and Ibrahim and Abdullah [17] for 1-MCP; Bailen *et al.* [20] for activated carbon and Haffez [30] for potassium permanganate.

1-MCP has important effects of delaying, slowing maturation and ripening fruit also maintaining postharvest quality when used during the storage period. The keeping quality of general appearance was improved by using 1-MCP attributed to the effect of 1-MCP on the reduction of weight loss and rot rate in mixed load of tomato and pepper fruits [17]. 1-MCP treatments have beneficial effects on fruit physiology such as delaying ripening of peppers [43].

The parameters which were related to ripening, such as color changes, firmness and weight loss evolved more slowly in tomato from packages with activated carbon because these parameters are known to be triggered and regulated by ethylene production in tomato, as well as other climacteric fruits [44].

In general, the interaction between postharvest treatments and storage periods was significant during storage. Results recorded that cantaloupe fruits and snap bean pods packed with 1-MCP at 5% treatment showed the best appearance. Cantaloupe fruits did not exhibit any

Table 2: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on general appearance (score) of cantaloupe fruits and snap bean pods during mixed load

	Cantaloupe fruits						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	9.00 a	9.00 a	9.00 a	9.00 a	9.00 a	8.33 b	8.89 A
T_2	9.00 a	9.00 a	9.00 a	9.00 a	8.33 b	7.67 c	8.67 AB
T_3	9.00 a	9.00 a	9.00 a	9.00 a	7.67 c	7.00 d	8.44 B
T_4	9.00 a	9.00 a	9.00 a	8.33 b	7.00 d	6.00 e	8.06 C
T_5	9.00 a	9.00 a	8.33 b	6.33 e	5.00 f	3.00 g	6.78 D
T_6	9.00 a	9.00 a	6.33 e	5.00 f	3.00 g	1.00 h	5.56 E
Means	9.00 A	9.00 A	8.44 B	7.78 C	6.67 D	5.50 E	
	Snap bean pods						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	9.00 a	9.00 a	9.00 a	8.33 ab	7.67 b-d	7.00 d-f	8.33 A
T_2	9.00 a	9.00 a	9.00 a	8.33 ab	7.00 d-f	5.00 h	7.89 B
T_3	9.00 a	9.00 a	9.00 a	7.67 b-d	7.00 d-f	4.33 h-j	7.67 B
T_4	9.00 a	9.00 a	8.00 bc	6.67 e-g	4.67 hi	3.33 kl	6.78 C
T_5	9.00 a	9.00 a	7.33 c-e	6.00 g	4.00 i-k	2.67 l	6.33 D
T_6	9.00 a	8.33 ab	6.33 fg	3.67 jk	1.33 m	1.00 m	4.94 E
Means	9.00 A	8.89 A	8.11 B	6.78 C	5.28 D	3.89 E	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x]T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5 potassium permanganate at 5g, T_6: control.

changes in GA till the end of storage period (20 days of storage at 5°C) but snap bean pods rated good appearance at the same period, while activated carbon at 5g or 10g treatments rated good appearance at the end of storage in cantaloupe fruits but in snap bean pods gave good appearance after 16 days of storage. On the other hand, untreated control had the unsalable appearance after 20 days of storage at 5°C in cantaloupe fruits and snap bean pods.

Firmness: Data in Table (3) indicate that there was a significant reduction in firmness of cantaloupe fruits and snap bean pods during mixed load by the prolongation of storage period. These results were in agreement with those obtained by Atress and Attia [40] on cantaloupe fruits and Ubhi *et al.* [45] and Gad El-Rab [32] on snap bean.

Concerning various treatments, data revealed that all postharvest treatments of cantaloupe fruits and snap bean pods had significant effects on firmness as compared to untreated control during storage. However, mixed load of cantaloupe fruits and snap bean pods packed with 1-MCP at 5% or activated carbon at 5g gave the highest value of firmness during storage followed by activated carbon at 5g or 10g treatments with significant differences between them, while the other treatments were less effective in this concern. The lowest value of firmness was obtained from untreated control. These results were in agreement with those reported by Atress and Attia [40], Zulferiyenni *et al.* [46], Ibrahim and Abdullah [17] and Poyesh *et al.* [34] for 1-MCP; Bailen *et al.* [20] and Bailen *et al.* [37] for activated carbon and Haffez [30] for potassium permanganate.

The faster reduction in firmness of cantaloupe and snap bean in untreated control may be due to cantaloupe high ethylene producers which occurs the degradation of the middle lamella of the cell wall and the intracellular of fruits [47].

The softening process is closely associated with ethylene production from the muskmelon fruits. Muharrem *et al.* [48] found that the 1-MCP induced firmness retention was accompanied by significant suppression of electrolyte leakage of mesocarp tissue, providing evidence that membrane dysfunction might contribute to softening of Galia melon. Also, Poyesh *et al.* [34] found that 1- MCP reduced ethylene-receptor bindings resulting in less activities of cell wall-degrading enzymes like cellulase, polygalacturonase and pectinesterase.

Table 3: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on firmness (g/ cm^2) of cantaloupe fruits and snap bean pods during mixed load

	Cantaloupe fruits						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	18.62 a	18.47 ab	18.23 a-d	17.82 d-f	17.42 fg	15.87 kl	17.74 A
T_2	18.62 a	18.35 a-c	17.95 c-e	17.00 gh	16.42 ij	14.43 n	17.13 B
T_3	18.62 a	18.10 b-e	17.73 ef	16.63 h-j	15.73 kl	13.45 o	16.71 C
T_4	18.62 a	18.02 b-e	16.78 hi	16.20 jk	14.67 mn	12.22 q	16.08 D
T_5	18.62 a	17.87 d-f	16.45 ij	15.03 m	12.88 p	10.37 s	15.20 E
T_6	18.62 a	17.63 ef	15.57 l	13.55 o	10.95 r	8.22 t	14.09 F
Means	18.62 A	18.07 B	17.12 C	16.04 D	14.68 E	12.43 F	
	Snap bean pods						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	22.67 a	22.42 ab	22.12 b-d	21.77 de	20.52 h	19.10 jk	21.43 A
T_2	22.67 a	22.23 bc	21.80 de	21.23 fg	19.47 ij	17.18 m	20.76 B
T_3	22.67 a	22.07 b-d	21.58 ef	20.60 h	19.05 jk	15.37 o	20.22 C
T_4	22.67 a	21.92 c-e	21.22 fg	19.88 i	18.30 l	14.95 o	19.82 D
T_5	22.67 a	21.87 c-e	20.93 gh	19.47 ij	17.33 m	13.83 p	19.35 E
T_6	22.67 a	21.70 de	20.75 h	18.80 k	16.13 n	12.90 q	18.83 F
Means	22.67 A	22.03 B	21.40 C	20.29 D	18.47 E	15.56 F	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x]T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5: potassium permanganate at 5g, T_6: control

Table 4: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on color (L value) of cantaloupe fruits and snap bean pods during mixed load

	Cantaloupe fruits						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	65.78 a	65.71 a	65.53 ab	65.33 a-c	63.94 d-f	63.67 e-g	64.99 A
T_2	65.78 a	65.52 ab	65.12 a-d	64.75 a-e	61.10 h	59.72 ij	63.67 B
T_3	65.78 a	65.40 ab	64.87 a-e	64.42 b-f	60.51 hi	58.73 j	63.28 B
T_4	65.78 a	65.22 a-c	64.61 a-e	63.87 e-g	59.57 ij	56.75 k	62.63 C
T_5	65.78 a	65.18 a-c	64.17 c-f	63.30 fg	58.76 j	54.43 l	61.94 D
T_6	65.78 a	64.85 a-e	63.68 e-g	62.67 g	56.83 k	51.36 m	60.86 E
Means	65.78 A	65.31 A	64.66 B	64.06 C	60.12 D	57.45 E	
	Snap bean pods						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	44.38 a	44.04 ab	43.89 ab	43.73 a-c	41.26 ef	39.75 gh	42.84 A
T_2	44.38 a	43.91 ab	43.47 a-c	42.73 cd	39.45 h	36.76 jk	41.78 B
T_3	44.38 a	43.76 a-c	42.26 de	41.13 f	37.83 ij	34.65 l	40.67 C
T_4	44.38 a	43.64 a-c	40.82 fg	39.38 h	36.40 k	33.12 m	39.62 D
T_5	44.38 a	43.40 a-c	39.92 gh	38.16 i	33.63 lm	29.96 n	38.24 E
T_6	44.38 a	43.18 b-d	39.68 h	37.71 ij	30.44 n	26.72 o	37.02 F
Means	44.38 A	43.66 B	41.67 C	40.47 D	36.50 E	33.49 F	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x]T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5: potassium permanganate at 5g, T_6: control

As regards the effect of activated carbon, the addition of activated carbon significantly reduced the firmness losses during cold storage, which could be attributed to the lower ethylene accumulation, thus retarded softness in tomato fruits [37].

In general, the interaction between postharvest treatments and storage periods was significant. After 20 days at 5°C, the highest value of firmness was recorded from mixed load of cantaloupe fruits and snap bean pods treated with 1-MCP at 5%, while the lowest value of firmness was obtained from untreated control at the same period.

Color (L value): Data in Table (4) indicate that there was a significant decrease in L value in mixed load of cantaloupe fruits and snap bean pods for all treatments during storage resulted in darker color. These results were in agreement with those obtained by Atress and Attia [40] on cantaloupe fruits and Ubhi *et al.* [45] on snap bean pods. Ardakani and Mostofi [49] showed that decreasing in L value relates to water loss in fruit.

Concerning the effect of postharvest treatments, data showed that there were significant differences among postharvest treatments and untreated control during storage. In cantaloupe fruits the highest value of L value was obtained from fruits packed with 1-MCP at 5% followed by activated carbon at 5g or 10g treatments with no significant differences between them during storage at 5°C resulted lighter color, while in snap bean pods the highest value of L value was obtained from pods packed with 1-MCP at 5% and activated carbon at 5g with significant differences between them resulted in lighter color. However, the lowest value of L value was obtained from control, resulted in darker color. These results were in agreement with Machado *et al.* [38], Massolo *et al.* [50] and Ibrahim and Abdullah [17] for 1-MCP and Haffez [30] for potassium permanganate.

Poyesh *et al.* [34] revealed that the mature green tomato fruit treated with 1-MCP were significantly delayed in color changes after 1, 2 and 3 weeks during storage at ambient temperature as compared to the control.

Color (B Value) of Cantaloupe Fruits: Data in Table (5) indicated that there was a significant increase in b value of cantaloupe fruits which stored together with snap bean pods was noticed with prolonging the storage period during storage. These results were in agreement with those obtained by Atress and Attia [40] on cantaloupe fruits. The color of cantaloupe fruits became yellow to orange with the storage time, which may be due to the breakdown of chlorophyll and synthesis of carotinoides, a pigment contributing to orange color in cantaloupe fruit [48].

Watkins and Nock [47] reported that cantaloupes are high ethylene producers, C_2H_4 accelerates chlorophyll degradation and the appearance of yellow or orange colors. C_2H_4 also promotes ripening of the pulp.

As for the postharvest treatments, data revealed that the untreated control of cantaloupe fruits had developed a uniformly yellow appearance (color stage 5) according to Fallik *et al.* [25] after 16 days at 5°C and had developed a full orange appearance (color stage 6) at the end of storage (the highest b value). In contrast, 1-methylcyclopropane at 5% or activated carbon at 5g were the most effective treatments for reducing changes of color with significant differences between them during storage, the surface color of 1-methylcyclopropane at 5% treatment never exceeded light yellow color (the lowest b value) at the end of storage period. These results were in agreement with Muharrem *et al.* [48] and Atress and Attia [40] for 1- MCP and Haffez [30] for potassium permanganate. Muharrem *et al.* [48] reported that cantaloupe fruits treated with 1-MCP delayed fruit ripening and reduce color change, thus extending the shelf life of cantaloupe fruits.

Jiang and Fu [51] found that differential effects of 1-MCP on color development depend on the multiplicity of pigment changes contributing to final fruit color (chlorophyll degradation, selective pigment synthesis or both) and their relative dependency on ethylene responsiveness. Also, they added that 1-MCP acts as high affinity noncompetitive inhibitor of ethylene action.

Potassium permanganate absorbs ethylene which produced by climacteric fruits, resulted in lower activity of chlorophyllase and consequence reduced color change and chlorophyll degradation and fruit maturity faced to a delay [52].

Color (Hue Angle Values) of Snap Bean Pods: A change in hue angles of snap bean pods is good indicator of senescence. As shown in Table (6) it is showed that the hue angle values of snap bean pods which stored with cantaloupe fruits gradually decreased as the storage period extended, indicating that snap bean pods turned to slight yellow as the storage period prolonged. These results were in agreement with those reported by Mohamedien *et al.* [53].

Table 5: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on color (b value) of cantaloupe fruits during mixed load

	Cantaloupe fruits						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	35.72 p	37.23 o	39.98 n	40.22 mn	40.44 l-n	41.42 k-m	39.17 E
T_2	35.72 p	37.47 o	41.63 j-l	42.12 jk	42.92 ij	44.11 hi	40.66 D
T_3	35.72 p	37.67 o	43.97 hi	44.36 gh	45.10 f-h	46.34 d-f	42.19 C
T_4	35.72 p	37.77 o	45.68 e-g	46.30 d-f	46.86 c-e	48.38 b	43.45 B
T_5	35.72 p	37.96 o	46.51 de	46.99 b-e	47.66 b-d	49.81 a	44.11 A
T_6	35.72 p	38.34 o	46.94 c-e	47.48 b-d	48.25 bc	50.44 a	44.53 A
Means	35.72 E	37.74 D	44.12 C	44.58 C	45.20 B	46.75 A	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x]T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5:potassium permanganate at 5g, T_6: control.

Table 6: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on color (hue angle h°) of snap bean pods during mixed load

	Snap bean pods						
	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	116.90 a	116.70 ab	116.30 a-c	115.60 c-g	114.40 ij	113.00 kl	115.50 A
T_2	116.90 a	116.60 ab	115.90 b-f	115.00 f-i	113.50 k	111.70 m	114.90 B
T_3	116.90 a	116.40 a-c	115.50 c-g	114.60 h-j	112.20 lm	110.30 n	114.30 C
T_4	116.90 a	116.30 a-c	115.40 d-h	113.70 jk	111.80 m	108.90 o	113.80 D
T_5	116.90 a	116.20 a-d	115.20 e-i	113.00 kl	109.90 n	106.50 p	113.00 E
T_6	116.90 a	116.00 b-e	114.80 g-i	112.20 lm	105.50 q	95.16 r	110.10 F
Means	116.90 A	116.40 B	115.50 C	114.00 D	111.20 E	107.60 F	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x]T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5: potassium permanganate at 5g, T_6: control

Concerning the effect of postharvest treatments, data showed that all treatments had significantly higher hue angle values as compared with untreated control which gave the lower value of hue angle as an important degreening or intense yellowing. On the other hand, snap bean pods packed with 1-MCP at 5% or activated carbon at 5g were the most effective treatments in reducing the loss of hue angle values indicated that pods retained more green color (higher value of hue angle) with significant differences between them during storage. These results were in agreement with Massolo *et al.* [50] and Falagan and Terry [54] for 1-MCP.

The color changes in untreated of snap bean pods may be due to pods exposure to ethylene (which produce from cantaloupe fruits) can promote yellowing, browning and shorten the storage life [47]. Removal of C_2H_4 or inhibition of its action by using 1-MCP or activated carbon can delay color changes in storage and prolong the storage life of snap bean pods. Saftner *et al.* [55] and Zanella [56] found that the loss of greenness of the background colour was inhibited by 1-MCP.

Total Soluble Solids Percentage: Data in Table (7) indicated that total soluble solids (TSS) of cantaloupe fruits and snap bean pods during mixed load were significantly decreased with the prolongation of storage period. Similar results were obtained by Haffez [30] on cantaloupe fruits and Kinyuru *et al.* [57] on snap bean pods. The reduction in TSS content during storage may be due to the higher rate of sugar loss through respiration than the water loss through transpiration [58].

Regarding the effect of postharvest treatments, data revealed that there were significant differences between postharvest treatments and untreated control in TSS% of cantaloupe fruits and snap bean pods during storage. Mixed load of cantaloupe fruits and snap bean pods treated with 1-methylcyclopropane at 5% or activated carbon at 5g retained more TSS percentage with significant differences between them, followed by activated carbon at 10g. However, potassium permanganate at 2.5g or 5g was less effective in this concern. The lowest values of TSS% were obtained from untreated control. These results were in agreement

Table 7: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on total soluble solids % of cantaloupe fruits and snap bean pods during mixed load

	Cantaloupe fruits						
	Storage period in days						
Treatments [x]	Start	4	8	12	16	20	Means
T_1	10.67 a	10.62 a	10.43 a-d	10.28 b-e	9.80 g-i	8.88 lm	10.11 A
T_2	10.67 a	10.53 ab	10.18 c-f	9.93 f-i	9.15 kl	8.55 no	9.84 B
T_3	10.67 a	10.50 a-c	10.02 e-h	9.77 hi	8.35 o	7.62 p	9.49 C
T_4	10.67 a	10.38 a-d	9.87 f-i	9.33 jk	7.80 p	6.95 q	9.17 D
T_5	10.67 a	10.12 d-g	9.65 ij	8.87 l-n	7.22 q	6.35 r	8.81 E
T_6	10.67 a	9.87 f-i	9.35 jk	8.65 m-o	6.55 r	5.00 s	8.35 F
Means	10.67 A	10.34 B	9.92 C	9.47 D	8.14 E	7.23 F	
	Snap bean pods						
	Storage period in days						
Treatments [x]	Start	4	8	12	16	20	Means
T_1	5.05 a	5.00 ab	4.88 a-c	4.82 b-d	4.73 c-e	4.68 c-f	4.86 A
T_2	5.05 a	4.85 a-c	4.70 c-f	4.48 f-h	4.15 j-l	4.03 kl	4.54 B
T_3	5.05 a	4.73 c-e	4.53 e-h	4.25 i-k	3.97 l	3.72 m	4.38 C
T_4	5.05 a	4.67 c-f	4.48 f-h	4.18 i-l	3.62 mn	3.43 no	4.24 D
T_5	5.05 a	4.62 d-g	4.37 h-j	4.00 l	3.33 op	3.10 q	4.08 E
T_6	5.05 a	4.40 g-i	4.08 kl	3.70 m	3.13 pq	2.65 r	3.84 F
Means	5.05 A	4.71 B	4.51 C	4.24 D	3.82 E	3.60 F	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x] T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5: potassium permanganate at 5g, T_6: control

with those obtained by Atress and Attia [40], Zulferiyenni *et al.* [46] and Ibrahim and Abdullah [17] for 1-MCP, Bailen *et al.* [20] for activated carbon and Haffez [30] and Kostekli *et al.* [24] for potassium permanganate.

Maintaining total soluble solids (TSS) of cantaloupe fruits and snap bean pods during mixed load by using 1-MCP, activated carbon and potassium permanganate may be due to these materials remove or absorb exogenous ethylene from atmosphere surrounding produce which decreased respiration rate and physiological changes of fruits during storage [36, 20, 24].

In general, the interaction between postharvest treatments and storage periods was significant, data revealed that cantaloupe fruits and snap bean pods treated with 1-MCP at 5% or activated carbon at 5g maintained the highest TSS% during all storage periods, while untreated control gave the lowest ones.

Ascorbic Acid Content: Data in Table (8) showed that ascorbic acid content of cantaloupe fruits and snap bean pods during mixed load decreased significantly with the prolongation of storage period. Similar results were obtained by Haffez, [30] on cantaloupe fruits and Shehata *et al.* [31] on snap bean pods). The reduction in ascorbic acid content during storage might owe much to the higher rate of sugar loss through respiration than the water loss through transpiration [58].

Concerning the effects of postharvest treatments, data showed that all postharvest treatments were effective in preventing ascorbic acid degradation during storage as compared with untreated control. Moreover, mixed load of cantaloupe fruits and snap bean pods treated with 1-methylcyclopropane at 5% or activated carbon at 5g were the most effective treatments in maintaining ascorbic acid contents with significant differences between them, followed by activated carbon at 10g. However, potassium permanganate at 2.5g or 5g was less effective in this concern. The lowest values of ascorbic acid content resulted in untreated control. These results were in agreement with those obtained by Budu and Joyce [42], Fang *et al.* [33] and Ibrahim and Abdullah [17] for 1-MCP and Haffez [30] and Kostekli *et al.* [24] for potassium permanganate.

Kostekli *et al.* [24] found that all the samples treated with potassium permanganate ethylene absorber sachets showed a higher content in ascorbic acid content at the end of the storage than the samples without ethylene absorbers. It is stated that potassium

Table 8: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on ascorbic acid content (mg/100 g f.w) of cantaloupe fruits and snap bean pods during mixed load

	Cantaloupe fruits						
	Storage period in days						
Treatments [x]	Start	4	8	12	16	20	Means
T_1	36.15 a	36.02 ab	35.10 de	33.83 hi	32.75 kl	32.23 lm	34.35 A
T_2	36.15 a	35.83 a-c	34.77 ef	32.93 jk	32.07 m	29.92 qr	33.61 B
T_3	36.15 a	35.58 b-d	34.15 gh	31.33 o	30.43 pq	28.23 s	32.65 C
T_4	36.15 a	35.32 cd	33.40 ij	30.53 p	27.72 s	26.07 u	31.53 D
T_5	36.15 a	34.48 fg	31.88 mn	29.60 r	26.87 t	24.52 w	30.58 E
T_6	36.15 a	34.08 gh	31.52 no	29.52 r	25.28 v	21.22 x	29.63 F
Means	36.15 A	35.22 B	33.47 C	31.29 D	29.19 E	27.03 F	
	Snap bean pods						
	Storage period in days						
Treatments [x]	Start	4	8	12	16	20	Means
T_1	15.95 a	15.87 a	15.80 ab	15.67 a-c	15.47 a-f	15.32 b-g	15.68 A
T_2	15.95 a	15.82 a	15.60 a-c	15.23 c-h	14.87 g-j	14.43 jk	15.32 B
T_3	15.95 a	15.73 ab	15.48 a-e	14.98 f-i	14.43 jk	13.58 mn	15.03 C
T_4	15.95 a	15.52 a-d	15.00 e-i	14.60 i-k	13.85 l-n	12.95 op	14.64 D
T_5	15.95 a	15.22 c-h	14.78 h-j	14.18 kl	13.37 no	12.08 q	14.26 E
T_6	15.95 a	15.10 d-h	14.57 i-k	13.88 lm	12.62 p	10.78 r	13.82 F
Means	15.95 A	15.54 B	15.21 C	14.76 D	14.10 E	13.19 F	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x] T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5: potassium permanganate at 5g, T_6: control

permanganate absorbs ethylene and degradates it to CO_2 and water which results in an increase of CO_2 content at storage atmosphere [59]. In addition, increase in concentration of carbon dioxide blocks the synthesis of endogenous ethylene [60], which is a ripening gas for fruits and vegetables.

In general, the interaction between postharvest treatments and storage periods was significant during storage. All postharvest treatments retained more ascorbic acid content compared to control during all storage periods at 5°C.

Gas Composition Inside the Packages: Cantaloupe fruits and snap bean pods are still alive and continue to respire after harvest [47, 45]. It is necessary to achieve proper gas composition in the packages, so it is very important to study the gas changes inside the package for all treatments used, moreover, the atmosphere analysis showed that 1-methylcyclopropane, activated carbon and potassium permanganate treatments had been modified the atmosphere inside the package.

Data in Tables (9, 10, 11) indicated that there was a significant decrease in O_2 % and increase in CO_2 % and ethylene concentration in the packages of mixed load cantaloupe fruits and snap bean pods during storage. Similar results were obtained by Haffez, [30] on cantaloupe fruits and Youssef *et al.* [61]; Gad El-Rab, [32] on snap beans. These results may be due to O_2 consumption and CO_2 production of pods and fruits during respiration process [30, 45]. The increase in ethylene during storage may be due to cantaloupes are typical climacteric fruits that exhibit characteristics rise in ethylene production during ripening [1].

Concerning the effect of postharvest treatments on gas composition inside the packages, data revealed that there were significant differences between postharvest treatments and untreated control. The gas composition inside the package treated with 1-MCP at 5% and activated carbon at 5g treatments had high O_2 levels and low CO_2 with significant differences between them followed by package treated with activated carbon at 10g. The levels of ethylene inside the package treated with 1-MCP at 5% and activated carbon at 5g treatments had low ethylene level with no significant differences between them followed by package treated with activated carbon at 10g and potassium permanganate at 2.5g with no significant differences between them. These results were in agreement with those obtained by Budu and Joyce [42]; Wrzodak and Gajewski [36] and Poyesh *et al.* [62] for 1-MCP, Bailen *et al.* [20] and Bailen *et al.* [37] for activated carbon and Silva *et al.* [63] for potassium permanganate.

Table 9: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on O_2 (%) of cantaloupe fruits and snap bean pods during mixed load

	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	20.80 a	20.57 a	20.05 b	19.60 c	18.08 e	17.45 f	19.42 A
T_2	20.80 a	19.90 bc	19.12 d	18.15 e	15.85 h	15.72 h	18.26 B
T_3	20.80 a	19.27 d	17.70 f	16.60 g	14.90 j	13.07 l	17.06 C
T_4	20.80 a	18.15 e	16.87 g	15.17 ij	13.07 l	11.33 n	15.90 D
T_5	20.80 a	17.43 f	15.23 i	14.45 k	12.25 m	10.50 o	15.11 E
T_6	20.80 a	16.80 g	14.28 k	12.92 l	10.45 o	8.18 p	13.91 F
Means	20.80 A	18.69 B	17.21 C	16.15 D	14.10 E	12.71 F	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x] T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5: potassium permanganate at 5g, T_6: control.

Table 10: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on CO_2 (%) of cantaloupe fruits and snap bean pods during mixed load

	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	0.03 s	0.04 s	0.15 s	0.23 s	0.67 qr	1.03 op	0.36 F
T_2	0.03 s	0.05 s	0.52 r	1.12 no	1.60 kl	2.25 ij	0.93 E
T_3	0.03 s	0.06 s	0.85 pq	1.47 lm	2.12 j	2.98 g	1.25 D
T_4	0.03 s	0.07 s	1.28 mn	2.40 i	2.83 gh	4.20 c	1.80 C
T_5	0.03 s	0.08 s	1.82 k	3.33 f	3.95 d	5.35 b	2.43 B
T_6	0.03 s	0.09 s	2.73 h	3.67 e	5.30 b	7.55 a	3.23 A
Means	0.03 E	0.07 E	1.23 D	2.04 C	2.74 B	3.89 A	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x] T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5:potassium permanganate at 5g, T_6: control.

Table 11: Effect of 1-methylcyclopropane, activated carbon and potassium permanganate treatments and storage period on ethylene concentration (ppm) of cantaloupe fruits and snap bean pods during mixed load

	Storage period in days						
Treatments[x]	Start	4	8	12	16	20	Means
T_1	0.00 l	0.00 l	0.00 l	0.00 l	0.00 l	0.03 kl	0.01 D
T_2	0.00 l	0.00 l	0.00 l	0.00 l	0.02 kl	0.07 j-l	0.01 D
T_3	0.00 l	0.00 l	0.00 l	0.05 j-l	0.12 h-k	0.22 f-h	0.06 C
T_4	0.00 l	0.02 kl	0.05 j-l	0.10 i-l	0.15 g-j	0.28 d-f	0.10 C
T_5	0.00 l	0.05 j-l	0.20 f-i	0.25 e-g	0.35 c-e	0.58 b	0.24 B
T_6	0.00 l	0.38 cd	0.45 c	0.57 b	0.75 a	0.85 a	0.50 A
Means	0.00 E	0.08 D	0.12 D	0.16 C	0.23 B	0.34 A	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

[x] T_1:1-methylcyclopropane at 5%, T_2: activated carbon at 5g, T_3: activated carbon at 10 g, T_4: potassium permanganate at 2.5g, T_5: potassium permanganate at 5g, T_6: control

The high O_2 and low CO_2 or ethylene levels inside the packages contained 1-MCP, activated carbon and potassium permanganate may be due to these materials removes or block exogenous ethylene from atmosphere surrounding produce which decreased respiration rate and consequently reduced the consumption of O_2 and decrease accumulation of CO_2 and ethylene levels inside the package [36, 20, 24, 48]. Also, Machado *et al.* [38] for 1-MCP on cantaloupe, Bailen *et al.* [20] for activated carbon on tomato and Sammi and Masud [39] for potassium permanganate on tomato found that these materials significantly delayed the onset of climacteric ethylene production and respiration rate in fruits during storage, which reduced O_2 consumption and decrease production of CO_2 or ethylene.

CONCLUSION

From the previous results, it could be clearly concluded that mixed load of cantaloupe fruits and snap bean pods packed with 1-methylcyclopropane at 5% was the most effective treatment for delaying fruits ripening of cantaloupe and maintaining quality of pods and fruits during storage which gave excellent appearance after 20 days of storage in cantaloupe fruits and rated good appearance in snap bean pods after the same period of storage at 5°C and 90-95 % RH.

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