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Ethylene Absorbents Improve the Shelf Life of Pointed Gourd (*Trichosanthes dioica* Roxb.) Fruits

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ABSTRACT

Studies have shown that laboratory made ethylene absorbents particularly Silica gel-permanganate and Celite-permanganate mixture can be used as post harvest treatment for enhancing the storability of pointed gourd fruits under ambient storage conditions (temperature 29.4-33.2°C and 68-73% RH) packed in 50µ polypropylene bags (20cm x 17cm size). There were seven treatments, replicated thrice and experiment was laid out in completely randomized design. The fruits stored with Celite-$KMnO_4$ mixture maintained higher sensory score of 7.67 in storage. The physiological loss in weight of fruits with Celite-$KMnO_4$ mixture documented minimum weight loss of 0.10% after 2 days and maximum of 1.47% at the end of storage. The fruits treated with Celite+$KMnO_4$ (4 and 8 g/kg) recorded no spoilage (0.00 %) respectively up to 8 days in storage. Celite+$KMnO_4$ 4 and 8g/kg showed higher disease reduction index (100.00 respectively) upto end of storage period. The chlorophyll content remained high on 4^{th} day, 6^{th} day as well as on 8^{th} days in storage with maximum retention of chlorophyll a (4.46 mg/g), chlorophyll b (2.13 mg/g) and total chlorophyll (6.58 mg/g) in Celite+$KMnO_4$ (8 g/kg) mixture. Hence, it is concluded that pointed gourd fruits stored with Celite-permanganate mixture can preserve the major post harvest attributes.

Key words: *Ethylene Absorbents, Silica Gel, Celite, Permanganate, Storage.*

INTRODUCTION

Pointed gourd (*Trichosanthes dioica* Roxb.) is a coveted member of Cucurbitaceae family which is also known as "King of gourds" because of its higher nutrient content and medicinal value. It is grown extensively in river beds in the states of Bihar, Uttar Pradesh, West Bengal and Assam in India. In West Bengal, it is one of the important vegetable crops, grown throughout the year except in the winter season. In spite of the abundant production, this nutrient packed vegetable fails to store under ambient conditions for longer period and loses its freshness within 2-3 days. Despite India being the second largest producer of vegetables globally, 30-35% of vegetables are lost at present owing to postharvest losses which increases many fold during rainy season.

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Due to lack of appropriate post harvest treatments, the fruits not only lose the quality but also a substantial loss in marketability. Ethylene is a major hazard to horticultural crops among several post harvest handling factors contributing to the loss of the produce. Ethylene is a colourless, odourless, tasteless gas that has many effects in plant physiology and is active in such small amount that it is considered as a plant hormone which mainly acts as a ripening hormone. A concentration of ethylene in air of 0.1 µL L^{-1} is the threshold level for physiological activity[1]. It accelerates the process of chlorophyll degradation and induces yellowing of green tissues, consequently deterioration in quality and finally consumer's preference in purchasing such vegetables. These risks can be mitigated by absorbing the ethylene produced from the fruits and oxidizing them. It is recorded that pointed gourd shows non-climacteric type of behaviour and produces lesser amount of ethylene[2]. So, storing the pointed gourd fruits with potassium permanganate ($KMnO_4$) which is an effective ethylene oxidizer[3] can enhances storability and preserves qualitative characters. This can be achieved by using potassium permanganate impregnated onto porous inert minerals such celite, vermiculite, alumina, zeolite and clay[4]. A range of commercial potassium permanganate products is available like Purafil, Ethysorb, Bloomfresh etc. Several studies have shown that $KMnO_4$ applications delay fruit softening and increase postharvest life[5,6,7,8]. The preparation and application of Silica gel-potassium permanganate and Celite-potassium permanganate mixture is relatively easy and has the benefit of low cost. Furthermore, polypropylene packaging provides modified atmosphere which is one the most accepted methods for extending the shelf life of perishable products by altering the relative proportion of gases that surrounds the produce and consequently reduces decaying, softening and enhances shelf life.

The experiment was planned with the hypothesis that storing of the fruits along with ethylene absorbent like potassium permanganate and packed in plastic films packages can extend the storability as well as the marketability. The present investigation was therefore has been undertaken with the objective to study the relative effectiveness of Silica gel-permanganate and Celite-permanganate mixture as ethylene absorbents on the storage behaviour of pointed gourd.

MATERIALS AND METHODS

The experiment was carried out in the laboratory conditions of the Department of Post Harvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. Fresh fruits of pointed gourd cv. Kajli were used for the present experiment. Fruits of uniform colour, size and maturity, without injuries were sorted out and washed. The fruits were washed with chlorine (100 ppm) water for 10 minutes using sodium hypochlorite (4.4 % w/w, as a source of chlorine). Then they were surface dried by keeping under fan in an airy place. The fruits were packed in 50 micron (µ) polypropylene bags (20 cm x 17 cm size) containing Silica gel-permanganate and Celite mixture-permanganate 2g, 4g and 8g per kg of fruits respectively. The bags were sealed and kept in storage room. The temperature and relative humidity of the atmosphere during the study period ranged from 29.4-33.2°C and 68-73% respectively. There were seven treatments viz., T_1- Control, T_2- Silica gel + $KMnO_4$- 2 g/kg, T_3- Silica gel + $KMnO_4$- 4 g/kg, T_4- Silica gel + $KMnO_4$- 8 g/kg, T_5- Celite + $KMnO_4$- 2 g/kg, T_6- Celite + $KMnO_4$- 4 g/kg, T_7- Celite + $KMnO_4$- 8 g/kg. The Silica gel-permanganate mixture was prepared in the laboratory by mixing 120 mL of 0.1 M $KMnO_4$ with 100 g of 16- mesh silica gel and drying the slurry at 110°C for 16 hours[9]. Celite mixture-permanganate mixture was prepared by spreading 500g $KMnO_4$ on 375 g of celite in a dish and adding 600 mL of water so that the permanganate would permeate the celite[10]. The analysis of data obtained in experiments

was analyzed by Completely Randomized Design with three replications, by adopting the standard statistical procedures[11]. The means between treatments were compared by Duncan's multiple range tests[12] (DMRT).

Sensory evaluation: During the period of study, observations on sensory properties were estimated by using 9-point Hedonic scale for their sensory characteristics like appearance, texture and overall acceptability. The scores were assigned from extremely liked (9) to disliked extremely[13] (1).

Physiological loss in weight (PLW): The weight of individual fruit in the experiment was taken on the day of observation and the percentage of loss in weight on the day of observation was calculated on the basis of the initial weight and expressed in percentage.

$$\text{PLW (\%)} = \frac{\text{Initial fruit weight} - \text{Weight of fruit on observation day}}{\text{Initial fruit weight}} \text{ x } 100$$

Spoilage: Spoilage percentage was observed after every 48 hours and was calculated as described below.

$$\text{Spoilage (\%)} = \frac{\text{Number of decayed fruits at the time of sampling}}{\text{Initial number of fruits}} \text{ x } 100$$

Disease reduction index (DRI): The disease reduction index was estimated from the numbered fruits of each experimental lot at each date of observation and disease reduction index was calculated by the following formula[14].

$$\text{DRI} = \frac{\text{Percent disease in control} - \text{Percent disease in treatment}}{\text{Percent disease in control}} \text{ x } 100$$

Chlorophyll content: Chlorophyll a, b and total chlorophyll was extracted in 80% acetone and absorption was measured at 663 nm and 645 nm by spectrophotometer (Systronics Spectrophotometer 166) and expressed as mg chlorophyll per gram of fresh tissue at regular time interval. Using the absorption coefficients, the amount of chlorophyll is calculated using the following equations[15].

mg chlorophyll a/ g tissue = 12.7 (A_{663}) – 2.69 (A_{645}) x $\frac{V}{1000 \times W}$

mg chlorophyll b/ g tissue = 22.9 (A_{645}) – 4.68 (A_{663}) x $\frac{V}{1000 \times W}$

and mg total chlorophyll/ g tissue = 20.2 (A_{645}) + 8.02 (A_{663}) x $\frac{V}{1000 \times W}$

where, A = absorbance at specific wavelengths

V = final volume of chlorophyll extract in 80% acetone

W = fresh weight of tissue extracted.

RESULTS AND DISCUSSION

The sensory properties of pointed gourd fruits evaluated on the base of sensory score are presented in Table 1. In sealed polypropylene bags the sensory score decreased in all treatments which were fair to non-acceptable after 8 days in storage where T_7 (Celite + $KMnO_4$ 8 g/kg) was significantly superior to other treatments. The storage of fruits in sealed polypropylene bags stored with ethylene absorbents prevented the buildup of ethylene by oxidation to ethylene glycol, retarded enzymatic activity, respiration and activity of pathogens. These changes resulted in slower down the ripening and senescence, enhancing shelf life and maintaining fruit quality during storage. Furthermore, PP 50 µ thickness bags have attributed to limited permeability of gases (CO_2 and O_2) and water vapour, which reduced respiration rate, softening and slows down all the biochemical changes associated with ripening and prevents the development of spoilage organisms[16].

Table 1: Changes in the sensory properties of pointed gourd fruits in storage treated with the ethylene absorbents

Treatments	Sensory properties Days in storage			
	2	**4**	**6**	**8**
T_1	7.00 **a**	4.67 **a**	3.00 **a**	1.67 **a**
T_2	7.67 **abc**	6.00 **b**	5.67 **b**	4.00 **bc**
T_3	7.33 **ab**	5.67 **ab**	4.00 **a**	3.00 **ab**
T_4	8.33 **bcd**	7.67 **c**	6.67 **bc**	6.00 **de**
T_5	8.00 **abcd**	7.33 **c**	6.00 **b**	5.33 **cd**
T_6	8.67 **cd**	8.33 **cd**	8.00 **cd**	7.00 **ef**
T_7	9.00 **d**	9.00 **d**	8.67 **d**	7.67 **f**
C.D. (0.05)	1.22	1.09	1.49	1.49
SE(m) ±	0.40	0.36	0.49	0.49

(Means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)

(T_1- Control, T_2- Silica gel + $KMnO_4$ 2 g/kg, T_3- Silica gel + $KMnO_4$ 4 g/kg, T_4- Silica gel + $KMnO_4$ 8 g/kg, T_5- Celite + $KMnO_4$ 2 g/kg, T_6- Celite + $KMnO_4$ 4 g/kg, T_7- Celite + $KMnO_4$ 8 g/kg)

The physiological loss in weight of pointed gourd fruits amplified with enhancement in the extent of storage whether stored with or without ethylene absorbents. However, fruits with ethylene absorbents particularly with Celite-$KMnO_4$ mixture documented lesser weight loss at different phases in storage compared to fruits in control. The maximum physiological loss in weight was observed in control (2.21%) and minimum (1.47%) in T_7 (Celite + $KMnO_4$ 8 g/kg) by the end of 8th day (Table 2). Celite-$KMnO_4$ mixture markedly reduced the weight loss this can be attributed towards the barrier properties of polypropylene bags and ethylene oxidizing property of $KMnO_4$ and for it to be effective in oxidizing ethylene from the atmosphere around produce where natural convection and diffusion are the only driving forces giving contact between ethylene and the oxidant, the $KMnO_4$ needs to have a high surface area exposed to the atmosphere[4] and celite on which $KMnO_4$ was absorbed has high surface area compared to silica gel. Since, ripening was delayed in the presence of $KMnO_4$, tissue permeability decreased and reduction in weight loss in the fruits would be obvious[17].

Table 2: Changes in the physiological loss in weight of pointed gourd fruits in storage as affected by the ethylene absorbents

Treatments	Physiological loss in weight (%) Days in storage			
	2	**4**	**6**	**8**
T_1	0.90 **c** (1.38)	1.19 **f** (1.48)	1.38 **d** (1.54)	2.21 **d** (1.79)
T_2	0.85 **c** (1.36)	1.02 **e** (1.42)	1.36 **d** (1.53)	2.17 **d** (1.78)
T_3	0.87 **c** (1.37)	0.72 **d** (1.31)	1.22 **c** (1.49)	1.90 **c** (1.70)
T_4	0.14 **a** (1.07)	0.59 **bc** (1.26)	0.92 **b** (1.39)	1.65 **b** (1.63)
T_5	0.29 **b** (1.13)	0.67 **cd** (1.29)	1.20 **c** (1.48)	1.88 **c** (1.70)
T_6	0.12 **a** (1.06)	0.49 **ab** (1.22)	0.90 **b** (1.38)	1.63 **c** (1.62)
T_7	0.10 **a** (1.05)	0.44 **a** (1.20)	0.65 **a** (1.28)	1.47 **a** (1.57)
C.D. (0.05)	0.04	0.04	0.05	0.05
SE(m) ±	0.01	0.01	0.02	0.02

* figures in parenthesis indicates square root transformed values

(Means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)

(T_1- Control, T_2- Silica gel + $KMnO_4$ 2 g/kg, T_3- Silica gel + $KMnO_4$ 4 g/kg, T_4- Silica gel + $KMnO_4$ 8 g/kg, T_5- Celite + $KMnO_4$ 2 g/kg, T_6- Celite + $KMnO_4$ 4 g/kg, T_7- Celite + $KMnO_4$ 8 g/kg)

The data presented in Table 3 on percent of spoilage of pointed gourd fruits influenced by different combinations of silica gel and Celite with $KMnO_4$ showed highly significant results in storage. All the treatments along with control showed no spoilage up to 6 days in storage. Fruits in T_6 and T_7 (Celite + $KMnO_4$ - 4g/kg and 8 g/kg) recorded no spoilage (0.00 % respectively) up to 8 days and control recorded highest spoilage (50.84 %) by the end of storage period. Spoilage of the fruits was enhanced with the advancement of the storage period in all the treatments. During the post harvest storage, one of the major problems is the proliferation of opportunistic microorganisms that thrive on injured or senescent tissues. Application of $KMnO_4$ reduced spoilage due to its antifungal activity. The polypropylene packaging created a modified atmosphere with higher CO_2 levels and reduced O_2 concentration. During storage due to respiring tissue, O_2 in the vicinity is utilized and CO_2 released during respiration maintained their exchange of gases from the atmosphere that lead to reduction in transpiration losses, thereby reduce the desiccation of fruits and checking pathogen development, thus, maintaining better shelf-life and quality fruits[18].

Table 3: Influence of ethylene absorbents on spoilage of pointed gourd fruits

Treatments	Spoilage (%)			
	Days in storage			
	2	4	6	8
T_1	-	-	-	50.84 **d** (45.46)
T_2	-	-	-	32.93 **c** (35.00)
T_3	-	-	-	35.04 **c** (36.28)
T_4	-	-	-	27.68 **b** (31.73)
T_5	-	-	-	28.69 **b** (32.37)
T_6	-	-	-	0.00 **a** (0.81)
T_7	-	-	-	0.00 **a** (0.81)
C.D. (0.05)	-	-	-	1.81
SE(m) ±	-	-	-	0.59

* figures in parenthesis indicates angular transformed values

(Means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)

(T_1- Control, T_2- Silica gel + $KMnO_4$ 2 g/kg, T_3- Silica gel + $KMnO_4$ 4 g/kg, T_4- Silica gel + $KMnO_4$ 8 g/kg, T_5- Celite + $KMnO_4$ 2 g/kg, T_6- Celite + $KMnO_4$ 4 g/kg, T_7- Celite + $KMnO_4$ 8 g/kg)

The data presented in Table 4 on the effect of ethylene absorbents on the incidence of diseases in pointed gourd fruits specified that application of silica gel-$KMnO_4$ and Celite-$KMnO_4$ mixture recorded no spoilage up to 6 days in storage. Celite + $KMnO_4$ 4 g/kg and 8g/kg showed better DRI (100.00 respectively) at different days in storage than silica gel-$KMnO_4$ mixture. The fruits in control and other treatments showed a steady loss of protective ability to reduce the decay caused by spoilage organisms. The epidermal layer of pointed gourd provides a protective barrier against infection but plant pathogenic moulds and bacteria possess mechanisms to penetrate into external tissues. The growth of a number of post harvest pathogens like the development and sporulation of the decay causing fungi *Penicillium* sp. and *Botrytis cinerea* is directly stimulated by ethylene. In addition, several post harvest plant pathogens produce ethylene and this ethylene may compromise the natural defenses of the plant tissues[19]. Application of $KMnO_4$ enhances shelf-life of fruits by absorbing evolved ethylene, slowing ripening process and decreasing spoilage[17].

Table 4: Disease reduction index at different days of storage of pointed gourd

Treatments	Disease reduction index			
	Days in storage			
	2	4	6	8
T_1	100.00	100.00	100.00	0.00
T_2	100.00	100.00	100.00	55.94
T_3	100.00	100.00	100.00	51.10
T_4	100.00	100.00	100.00	65.92
T_5	100.00	100.00	100.00	54.60
T_6	100.00	100.00	100.00	100.00
T_7	100.00	100.00	100.00	100.00

(T_1- Control, T_2- Silica gel + $KMnO_4$ 2 g/kg, T_3- Silica gel + $KMnO_4$ 4 g/kg, T_4- Silica gel + $KMnO_4$ 8 g/kg, T_5- Celite + $KMnO_4$ 2 g/kg, T_6- Celite + $KMnO_4$ 4 g/kg, T_7- Celite + $KMnO_4$ 8 g/kg)

The change in colour of pointed gourd fruits from green to yellow-orange continued over the storage period (Table 5). The initial chlorophyll a, chlorophyll b and total chlorophyll content of pointed gourd fruits were 6.86 mg/g, 3.27 mg/g and 10.13 mg/g respectively. This initial value decreased significantly with the storage time. The highest retention of chlorophyll a (4.46 mg/g), chlorophyll b (2.13 mg/g) and total chlorophyll (6.58 mg/g) was documented in T_7 (Celite + $KMnO_4$ 8 g/kg) and lowest in control at the end of storage period. The lower rate of decrease in chlorophyll content $KMnO_4$ treated fruits could be attributed to be slower ripening. The maturity of pointed gourd fruits results in chlorophyll degradation and synthesis of carotenoids and xanthophylls which in turn increases β-carotene content in fruits. Potassium permanganate absorbs the ethylene emanated by fruits. The high amount of CO_2 and low O_2 concentration in sealed polypropylene bags results in the low ethylene content, thus β-carotene and fruit maturity faced with a delay[20].

Table 5: Chlorophyll a, chlorophyll b and total chlorophyll content at different days in storage of pointed gourd

Treatments	Pigment content (mg/g)											
	Days in storage											
	2			4			6			8		
	Chlorophyll a	Chlorophyll b	Total chlorophyll	Chlorophyll a	Chlorophyll b	Total chlorophyll	Chlorophyll a	Chlorophyll b	Total chlorophyll	Chlorophyll a	Chlorophyll b	Total chlorophyll
T_1	4.00 **a**	1.90 **a**	5.91 **a**	3.49 **a**	1.66 **a**	5.15 **a**	2.85 **a**	1.36 **a**	4.20 **a**	1.94 **a**	0.92 **a**	2.86 **a**
T_2	4.39 **b**	2.09 **ab**	6.48 **ab**	3.77 **b**	1.80 **ab**	5.57 **ab**	3.08 **ab**	1.47 **a**	4.55 **ab**	2.39 **b**	1.14 **b**	3.53 **ab**
T_3	4.69 **b**	2.23 **b**	6.92 **b**	4.00 **b**	1.91 **bc**	5.91 **ab**	3.32 **b**	1.58 **ab**	4.90 **ab**	2.63 **c**	1.25 **b**	3.88 **bc**
T_4	5.80 **d**	2.76 **cd**	8.56 **cd**	4.44 **c**	2.12 **c**	6.56 **b**	3.82 **c**	1.82 **c**	5.63 **bc**	3.20 **d**	1.52 **c**	4.72 **cd**
T_5	5.37 **c**	2.56 **c**	7.93 **c**	4.35 **c**	2.07 **c**	6.42 **b**	3.78 **c**	1.80 **bc**	5.58 **bc**	3.09 **d**	1.47 **c**	4.57 **c**
T_6	6.06 **d**	2.88 **d**	8.94 **d**	5.14 **d**	2.45 **d**	7.59 **c**	4.46 **d**	2.12 **d**	6.58 **cd**	3.77 **e**	1.80 **d**	5.57 **d**
T_7	6.68 **e**	3.18 **e**	9.87 **e**	5.38 **d**	2.56 **d**	7.94 **c**	4.91 **e**	2.34 **d**	7.25 **d**	4.46 **f**	2.13 **e**	6.58 **e**
C.D. (0.05)	0.30	0.28	0.91	0.25	0.24	1.03	0.28	0.23	1.22	0.23	0.20	0.95
SEm ±	0.10	0.09	0.30	0.08	0.08	0.34	0.09	0.08	0.40	0.08	0.07	0.31

(Means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)

(T_1- Control, T_2- Silica gel + $KMnO_4$ 2 g/kg, T_3- Silica gel + $KMnO_4$ 4 g/kg, T_4- Silica gel + $KMnO_4$ 8 g/kg, T_5- Celite + $KMnO_4$ 2 g/kg, T_6- Celite + $KMnO_4$ 4 g/kg, T_7- Celite + $KMnO_4$ 8 g/kg)

CONCLUSION

It could be concluded that Celite-permanganate mixture as an ethylene absorbent was more promising as compared to Silica gel-permanganate mixture for the storage of pointed gourd fruits packed in polypropylene bags under ambient conditions. It has the potential to maintain sensory qualities, minimize physiological loss of weight, spoilage, higher disease reduction index and maintenance of pigments.

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