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EFFECT OF 1-METHYLCYLOPROPENE (1-MCP) ON POSTHARVEST QUALITY AND SHELF LIFE OF OKRA

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ABSTRACT

Fresh okra (*Abelmoschus esculentus* L.) is a perishable vegetable, which has a short postharvest life. Loss of quality in harvested okra is usually manifested with shriveling, toughening, and chlorophyll degradation would change the color and texture of fresh okra leading to rejection by the consumer. The actions of ethylene contribute to making above changes. In this study, the effects of fumigation using 1-Methylcyclopropene (1-MCP) at concentrations of 0.5 and 1 µL L-1on the postharvest quality and shelf life of Okra (variety Haritha) were investigated. Samples were stored at 28±2 °C for 12 days. Both 1-MCP concentrations showed lower weight loss, color change and crude fibre development compared to the control. The content of total soluble solids (TSS), disease incidence, marketable ability and shelf life also exhibited higher performance with both concentrations of 1-MCP. The only parameter that was not significantly affect ($p>0.05$) by the treatments was disease incidence. However, weight loss, color change, crude fibre content and the TSS content were maintained at satisfactory levels by fumigating with 1-MCP at 1 µL L-1 compared to that at 0.5 µL L-1and the control. The 1-MCP at 1µLL-1 resulted in the highest value for marketable ability and the lowest disease incidence. The shelf life of the fresh okra in the control was 7 days while 1-MCP treatments at 0.5 and 1µL L-1recorded a shelf life of 9 and 11 days, respectively. The results concluded that fumigating with 1-MCP at a concentration of 1µL L-1as a pre-storage treatment would maintain the postharvest quality, suppress fiber formation and extend postharvest life of okra.

Keywords: Okra, 1-MCP, Fibre formation, Quality, Shelf life

INTRODUCTION

Okra (*Abelmoschus esculentus* L., family: Malvaceae) is one of the widely consumed and economically viable vegetable crops grown in tropical and sub-tropical areas ((Naveed *et al.*, 2009; Oyelade *et al.*, 2003; Saifullah & Rabbani, 2009). Fresh okra is commonly used in various food items including soups, stews, curry and steamed vegetables. It is also a good source of fiber, protein (Ifon and Bassir, 1980), minerals and vitamin C (Achinewhu, 1983) and diet-viscous mucilage.

Fresh pods of okra is extremely perishable (Hardenburg *et al.*, 1986) and has a short shelf life due to high respiration and higher rate of water loss (Tamura and Minamide, 1984). Rapid and continuous changes of quality and chemical composition are main problems associated with okra after harvesting. Quality losses in harvested okra are usually manifested as increasing fiber content, shriveling, toughening, and chlorophyll degradation (Singh *et al.*, 1978) resulting insignificant changes in the pod color, texture and chemical composition of okra. These conditions affect the appearance of the pods leading to rejection by consumers.

Ethylene is a neutral plant hormone produced by fruits and vegetables. Internal ethylene concentration of fruits and vegetables trigger enzyme activities associated with respiration, chlorophyll degradation, softening, ripening and changes of chemical composition (Seymour, 1993: Lin *et al.*, 2009). Ethylene quickens the deterioration process of okra and reduces the market life of the pods. Exposure to exogenous ethylene reduces chlorophyll and the bright green color of the pod surface. Exposure to high concentrations of ethylene in storage may cause the pods to yellow (Lawford and Waters, 1990). Effect of ethylene could be reduced by storing the products at low temperature (7-10 °C), however, okra is sensitive to chilling injury at this temperature (Lyons and Breidenbach, 1987; Salunkhe and Desai, 1984).

The gaseous ethylene blocking compound 1-methyl cyclopropene (1-MCP), interacts with ethylene receptors and thereby prevents ethylene-dependent responses, has been used for decades to maintain postharvest quality of various products (Sisler *et al.*, 1995). The safety, toxicity and environmental profiles of 1-MCP with respect to humans, animals and the environment are extremely favorable. The compound has been used at

low concentrations, has a non-toxic mode of action and is chemically similar to naturally occurring substances (EPA, 2002). The 1-MCP has been registered and used commercially as a postharvest pre-treatment (Blankenship and Dole, 2003), and as a fumigant of fruits and vegetables to maintain the postharvest quality (Golding *et al.*, 1998).Therefore, the objective of this study was to investigate the effects of 1-MCP fumigation on postharvest quality parameters and shelf life of harvested okra during storage in Sri Lanka.

MATERIALS AND METHODS

Plant materials and treatments

Half mature green okra pods of the variety Haritha were harvested four to six days after flowering from the research farm at Girandurukotte in Sri Lanka, and carefully transported to the laboratory at the Agriculture Research Station, Girandurukotte. Okra samples were selected for uniformity in green color, size and free from defects or physiological disorders. Selected pods of okra were randomly divided into three lots with the first lot being fumigated with 0.5µL L-1of 1-MCP for three hours (Blankenship and Dole, 2003) at 28±2 °C, second lot with 1 µL L-1of 1-MCP for three hours at 28±2°C, and the third lot was used as the control without 1-MCP treatment. The experiment was arranged in a Complete Randomize Design (CRD) with four replicates. The fumigation process was done using an air tight glass chamber. The treated material was stored for 12 days at 28±2°C and 85% RH, and samples were drawn for data collection and analysis at two-day intervals. All samples were covered with low density polyethylene to control the water loss.

Measurements

Weight loss

The weight (g) of 10 randomly collected pods (g) was measured using an electronic balance with accuracy for three decimals, and the percentage of weight loss was calculated on fresh weight basis.

Total soluble solids

The content of total soluble solids (TSS) was measured by extracting a fresh juice sample of the treated product. The upper, middle and lower parts of the okra pods were used for making juice samples. Fresh juice was prepared by using a mortar and a pestle, and filtered using clean piece of cloth. The TSS content was measured using a Refractometer (Kyowa, Model 887352).

Crude fibre content

Okra was sliced and dried in the oven at 45 °C to a constant weight before the crude fibre analysis. Crude fibre content in the samples was measured following the sulfuric acid method (AOAC, 1990).

Disease incidence

Disease incidence was measured using the whole sample from day 0 to 12, and considering the disease incidences of initial stage as zero. The disease incidence was investigated using a ranking system (no symptoms at pod surface = 0, 1 – 20% = 2, 21- 40%= 4, 41 – 60% =6, 61 – 80% =8, 81 –100% =10).Scores were given for disease symptoms such as fungal attack, decay spots, decay areas, rotted areas and all pathogen attacks.

Pod color change

The change in pod color (green to yellow) of okra was also measured using a ranking methodi.e.100% green color (initial) = 10, >75 - <100 % green color = 7.5, >50 - <75% green color = 5.0, >25 - <50% green color=2.5, 0 - <25%green color = 0). Same okra samples that were used measure disease incidence were used to estimate the color change of the pod from day 0 to day 12. To compare the initial green color, a fresh okra sample of the same variety was harvested each day before taking the measurements.

Marketability

The marketability (percentage) was measured using a consumer panel consisting of 10 consumers. Consumers of the panel scored the samples based on the fresh appearance, pod shape, green color, toughening and shriveling (Abd-Allah *et al.*, 2010).

Shelf life

The shelf life of okra samples was determined using several standard indicators such as green color, appearance, toughening, water loss (shriveling), physical disorders and disease development (NARI, 1999).

Data analysis

Analysis of variance (ANOVA) was performed using the statistical analysis system (SAS) program version 9.0. Duncan's Multiple Range Test was conducted for mean separation at p=0.05.

RESULTS AND DISCUSSION

Effect of 1-MCP on weight loss

Both 1-MCP concentrations used reduced the weight loss in fresh okra compared to the control at 28±2°C (Figure 1). After day 2, the weight loss of the control increased significantly compared to both the 1-MCP treatments, reaching the maximum weight loss on day 8 (2.07%). The highest weight loss of okra treated with 0.5 and 1 µL L-1of 1-MCP was also observed on day 8 (1.4% and 1.2%, respectively). The reduction of weight loss could be due to the suppression of respiration rate. In general, ethylene blocker 1-MCP reduces or delays the increase in respiration rate (Blankenship and Dole, 2003). Many scientists have reported that 1-MCP treatments inhibited the level of increase of ethylene-induced respiration in fruits and vegetables (Golding *et al.*, 1998; Porat *et al.*1999; Fan and Mattheis, 2000a; Wills *et al.*, 2002). The weight loss was suppressed successfully by 1 and 0.5 µL L-1of 1-MCP treatments than in the control. Suppression of weight loss and respiration rate was correlated as 1-MCP reduced the respiration rate through inhibition of ethylene synthesis. The 1-MCP may block the normal feedback regulation of ethylene production and ethylene biosynthetic enzymes such as ACC oxidase, ACC synthase and

associated mRNA accumulation (Dong *et al.*, 2001). Results similar to the present study were reported by Golding et al. (1999), Fan and Mattheis (2000a), Porat et al. (1999) and Wills and Ku (2002) with different fruits and vegetables. However, the 1-MCP at the concentration of 1μL L-1 reduced the weight loss at a higher rate compared to at 0.5 μL L-1 and the control.

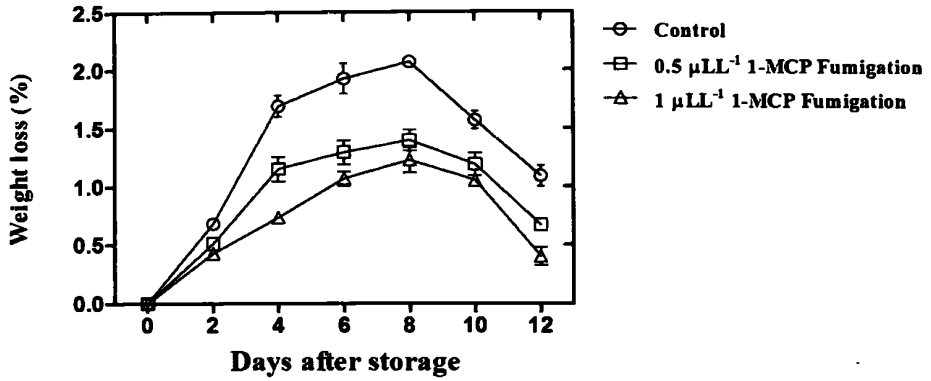

Figure 1. Effect of 1-MCP concentrations on weight loss of okra during storage at 28±2°C

Effect of 1-MCP on the content of total soluble solids

Many researchers have reported an increase in TSS in fruits during maturation and ripening due to degradation of starch into soluble sugar within the cell (Siriboon and Banlusilp, 2008; Pinto *et al.*, 2004; Cordenunsi and Lajolo, 1995). The total soluble solids content of all okra samples used in this study decreased from day 0 to 8 and started to increase thereafter (Figure 2). The reduction in TSS content is a typical character in okra during storage due to decrease in the content of viscous mucilage and soluble sugars with lignifications of tissues (Baxter and Waters, 1990). However both 1-MCP treatments retained the TSS at higher levels than in the control. Therefore the low lignification rate has a direct impact on the samples fumigated with 1-MCP. Joshi *et al.* (1984) also reported that the TSS content of okra declined with the reducing levels of viscous mucilage due to formation of crude fibre. The increased crude fiber content of okra samples (Figure 3) in this study provided evidence for this phenomenon. Increase of the TSS content after day 8 in all samples could be a result of higher water loss and increase on the concentration of TSS.

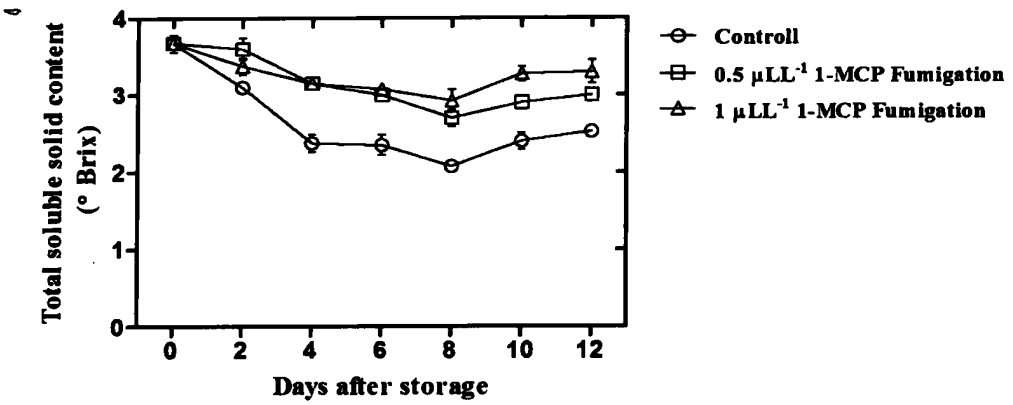

Figure 2. Effect of 1-MCP concentrations on total soluble solids of okra during storage at 28±2 °C

Effect of 1-MCP on crude fibre development

The crude fibre content of all samples increased with storage time (Figure 3). Many scientists have reported on the cell lignification and increasing cellulose and hemi-cellulose contents in okra with crop maturity (Famurewa and Olumofin, 2015; Lawford and Waters, 1990). Increase in crude fiber content of harvested okra stored at normal condition reported by Lawford and Waters (1990) and the results of the present study confirm this aspect. The crude fiber content of okra samples fumigated at 1-MCP concentrations were significantly lower ($p<0.05$) than the crude fiber content of the control from day 4 to day 12. These results suggest the relationship between ethylene production and the fibre development of okra after harvest. The 1-MCP is an anti-ethylene compound, which blocks ethylene receptors in the tissues (Sisler *et al.*, 1995) and prevents or delays the ethylene production. However, Cantwell and Suslow (2004) reported that exposure of okra to ethylene increases the toughness and pod yellowing. Hennion et al. (1992) reported that the exposure of harvested asparagus to ethylene accelerated the lignification and fibre formation (toughening) of asparagus spears. Haard *et al.* (1974) reported that tissue lignification and fiber formation of asparagus progresses rapidly at a temperature of about 10 °C and is accelerated by ethylene. The lower fibre content of okra fumigated with 1µL L-1of 1-MCPthan that in the concentration of 0.5 µL L-1suggest that the fiber formation of harvested okra has a direct relationship with the ethylene concentration.

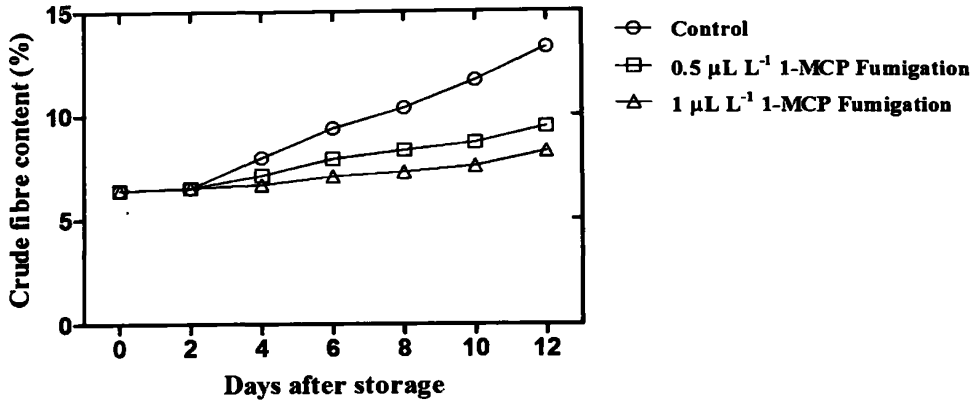

Figure 3. Effect of 1-MCP concentrations on crude fiber content of okra during storage at 28±2 °C

Effect of 1-MCP on the change of pod color

The bright green color of all okra samples started to change (green to yellow) after 2 days of storage. The color change of the control sample was more marked than those fumigated with 1-MCP (Figure 4). After day 12, 1-MCP at the concentration of 1µL L-1significantly conserved ($p<0.05$) the green color of okra than in those the control. Fernando *et al.*(2008)reported of the reducing of green color with the chlorophyll degradation of harvested okra at 25 °C. Yellowing of many fruits and vegetables due to chlorophyll degradation has been accelerated by ethylene (Sisler and Serek, 1999; Jiang *et al.*, 1999; Harris *et al.*, 2000).The1-MCP treatment has prevented or delayed chlorophyll degradation in a wide range of fruit and vegetables species through inhibition of the ethylene action (Golding *et al.*, 1998).However, results of the present study have confirmed that 1-MCP at concentrations of 1and 0.5 µL L-1have delay yellowing of okra. This is probably the result of delaying chlorophyll degradation through 1-MCP action. Delay in the loss of green color in both 1-MCP treatments confirmed that 1-MCP is slowing down of chlorophyll degradation process in okra after harvest.

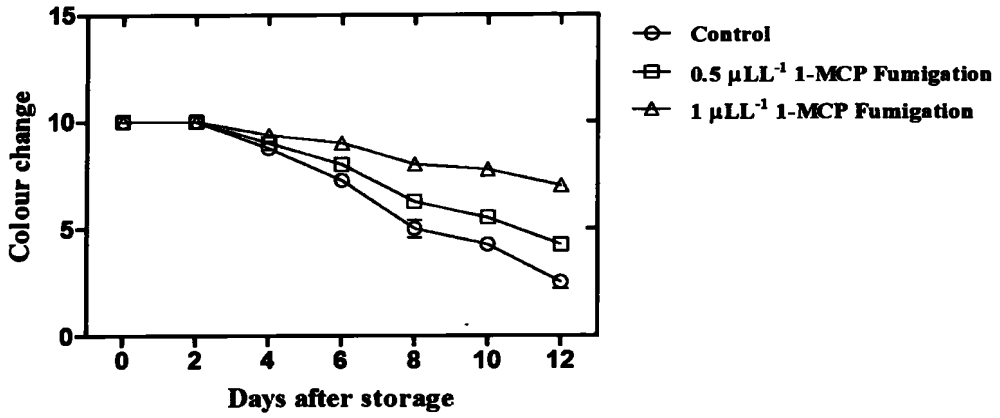

Figure 4. Effect 1-MCP concentrations on color change of okra during storage at 28±2 °C

Effect of 1-MCP on disease incidence

The disease incidence of all okra samples progressed during the storage (Figure 5). The disease incidence of okra treated with 1µL L-11-MCP was significantly low ($p<0.05$) compared to the control from day 4 to 12. The disease incidence of okra fumigated with 0.5µL L-1of 1-MCP and that in the control increased in a similar manner until day 6. No disease symptoms were observed in okra fumigated with 1-MCPA at 1µL L-1from day to 4. Thereafter, the disease incidence of okra in the control increased rapidly compared to okra treated with 1-MCP. Many scientists have reported of the action of 1-MCP against diseases and physiological disorders of fruits and vegetables (Blankenship and Dole, 2002). The 1-MCP treatments reduced the development of decay in avocado (Pesis *et al.*, 2002), pineapple (Selvarajah *et al.*, 2001) and apricots (Dong *et al.*, 2002). Furthermore, 1-MCP slowed down russet spotting of lettuce (Lactuca sativa) and broccoli (Fan and Mattheis, 2000b), and suppressed superficial scald by 30% in 'McIntosh' apple during air storage (Rupasinghe *et al.*, 2000a). Ciardi *et al.* (2001) observed that tomato treated with 1-MCP was resistant to some postharvest diseases. However, 1-MCP contributes to accelerating of some antioxidant enzymes of plant tissues through inhibition of ethylene evolution (Selvaraj *et al.*, 2001), could be a reason to the development of resistance in tissues through strengthening the natural defense mechanism in plant tissues (Ku *et al.*, 1999).

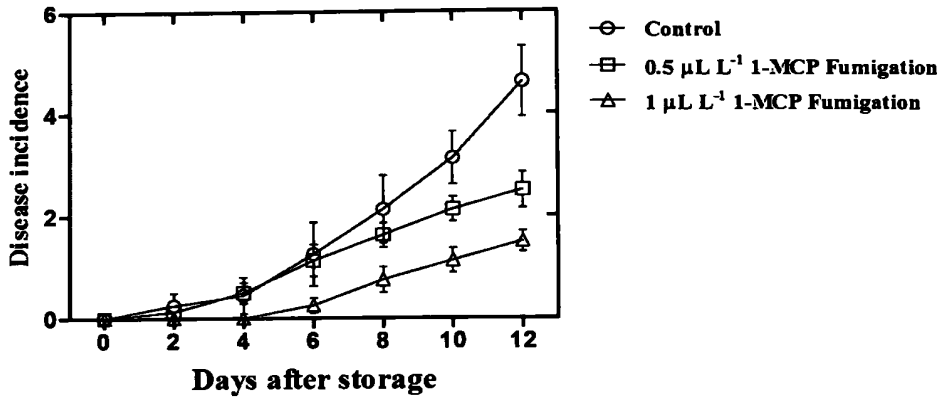

Figure 5. Effect of 1-MCP concentrations on disease incidence of okra, after harvest at 28±2°C.

Effect of 1-MCP on marketability

Marketability of all okra samples started to reduce after day 2of storage in a similar pattern. The marketability of okra samples treated with 1-MCP started declining later than those in the control (Figure 6).The marketability of okra in the control became zero at the 12th day of storage, while it was low compared to those fumigated with 1µL L-1of 1-MCP after day 6. The general consumer preference of okra depends on fresh appearance, pod shape, green color, toughening and shriveling, and disease development (Abd-Allah *et al.*, 2010) were maintained at acceptable levels after fumigation with 1-MCP (Figure 1, 3, 4 and 5).However okra fumigated with 1µL L-1of 1-MCP showed a better marketability than those treated with 0.5 µL L-1of 1-MCP.

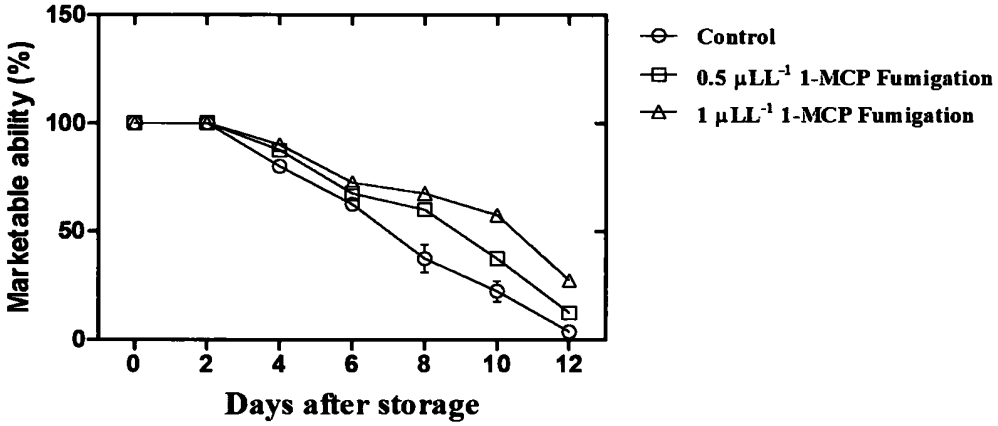

Figure 6. Effect of 1-MCP concentrations on marketable ability of okra, after harvest at 28±2 °C

Effect of 1-MCP on shelf life

Shelf life of okra samples determined at 50% marketability in the control, and fumigated with 0.5 and 1μL L-1of 1-MCP was 7, 9 and 11 days, respectively (Figure 7), based on standard criteria proposed by NARI (1990). The marketability of okra in the control reached 50% level at day 7 while those fumigated with 0.5 and 1μL L-1of 1-MCP reached the 50% marketability level at 9 and 11 days, respectively. Shelf life of okra fumigated with 1μL L-1of 1-MCP recorded the maximum shelf life (11 days) due to delayed chlorophyll degradation (Figure 4), fiber formation (Figure 3), water loss (Figure 1) and disease development (Figure 5).

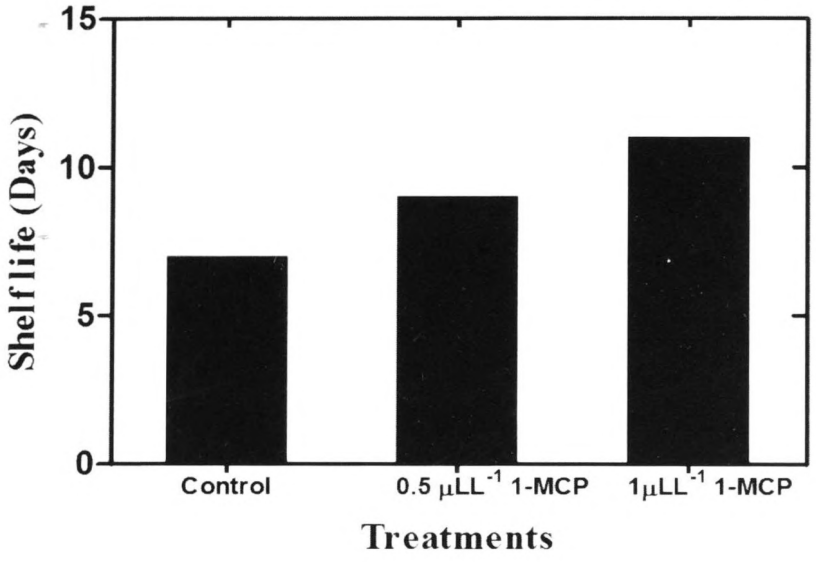

Figure 7. Effects of 1-MCP on shelf life of okra during storage at 28±2 °C

CONCLUSIONS

Fumigation of okra with 1-MCP is a favorable technology for the commercial application for maintaining quality, extending shelf life and reducing postharvest losses at storage temperature of 28±2 °C. The 1-MCP at 1μL L-1 showed better performance than 0.5μL L-1 on improving postharvest quality and shelf life of okra.

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