__Original Research Article__

Effect of 1-Methylcyclopropene Treatment on Shelf Life and Quality of Guava Fruits.

ABSTRACT

Storage of guava fruits by using refrigerators as postharvest treatment is commercially acceptable but is expensive, especially in developing countries. So, the present investigation was carried out with the objective to compare the efficacy of MCP-1 and their most effective concentrations for the shelf-life enhancement of guava fruits without any deterioration in fruit quality in the winter season at both cold and room-temperature storage conditions. Horticultural mature guava fruits were treated with 150, 300, and 600 pbb, and then stored at room temperature at 21°C, RH 45%, or cold storage at 6°C, RH 85%. The Results showed that the highest concentration of MCP-1 (600pbb) significantly ($P<0.05$) preserved fruit firmness, and organoleptic quality attributes. In addition, the fruit weight loss, decay percentage, titratable acidity (TA), total soluble solids (TSS), and fruit color development were significantly preserved compared to other treatments under both cold and room storage conditions. Generally, MCP-1 could maintain the quality of guava fruit combined with cold temperatures for 24 days. While 150 and 300 pbb MCP-1 preserved the quality of fruits for up to 20 days compared to untreated fruits for 16 days. Otherwise, treated fruits with 600pbb of MCP-1 kept at room storage temperature preserved fruits quality for up to 20 days compared with untreated fruits for up to 12 days stored at room storage condition. Hence, MCP-1 could be an alternative to cold storage, as it is more economical than cold storage, especially in developing countries.

Keywords: [MCP-1, Shelf life, Physical, and Chemical properties}

1. INTRODUCTION

Guava fruits (Psidium guajava) belong to the Myrtaceae family, are widely cultivated in tropical and subtropical countries, and are gaining popularity worldwide [1]. For instance, in Palestine, guava is mainly cultivated in the northern districts of the geographical area. Recently, guava fruit cultivation has increased rapidly, the area under cultivation in the West Bank has doubled from 2500 to 3500 donum in 2021, and production has also increased to a projected amount from 15 to 20 tons [2]. Guava fruit exhibits a climacteric pattern of respiration and ethylene production so is highly perishable in nature and suffers a great extent of post-harvest loss, which can be harvested at the early physiology maturity stage and stored for a few days as ripened fruits [3]. Generally, several physiological, biochemical, and structural changes occur during fruit ripening such as the degradation of starch to sugars, synthesis of pigments, volatile compounds, and partial solubilization of cell walls [4]. In addition, the quality of climacteric fruits is highly affected by postharvest conditions such as transportation and storage during ripening [5]. Several research showed climacteric fruit ripening can be controlled by several postharvest methods such as reducing the respiration rate and ethylene synthesis, storing fruits at low temperatures, and coating with various natural substances is the most efficient method of maintaining the quality of most fruits and delaying the of the climacteric period and thus delays ripening [6]. Otherwise, many studies have been devoted to describing MCP-1 as a postharvest treatment, it's widely used to extend fruit shelf life, provide fruit firmness, maintain fruit quality, and reduce the incidence of rot [7]. Previous results have shown that postharvest treatment with MCP-1 and packing material prolongs shelf life, reduces spoilage, and improves guava fruit quality by delaying the onset of senescence during storage [7]. Postharvest application of MCP-1, which could delay lignin and cellulose accumulation and delay senescence, has been widely reported in common beans [8], loquat fruit [9], pears [10], guava fruit [11], and plums [12]. In addition, postharvest application of MCP-1 can inhibits the expression of ETR2, and EIL1, and act as an inhibitor of ethylene rate production [13]. In addition, MCP-1 worked as interference with the ethylene link to its binding site representing a new and powerful tool for the postharvest management of climacteric fruits [7]. It has been demonstrated that the inhibition of the ethylene action delays ripening and senescence in several species of fruits, such as apples [14], and pears [15]. This study aims to explore the effect of MCP-1 on guava fruit ripening, on prolonging shelf-life, and quality during the postharvest storage periods at different temperature storage.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY.

2.1. Fruits Material.

Guava fruits were hand harvested at the commercial stage (horticultural maturity), were immediately transported to the postharvest laboratory of the National Agriculture Research Center (NARC), Qabatia-Jenin. Guava fruits free from damage, uniform size, color, and cleaned were selected for further treatments.

2.2. Post-harvest Treatments.

2.2.1. MCP-1 Preparation and Treated fruits

- The 1-MCP application procedure was followed as it was earlier published by [15]. Samples were kept at 1 ◦C before 1-MCP treatment. Three groups were treated with 1-MCP gas on the 4rd, 6th, and 8th day after harvest in an air-tight chamber at 1C for 24h.
- The fruits were divided to four set, each set contain 90 fruits. First set was treated with 600 ppb MCP-1 for 2 minutes. The second set for fruits treated with a moderately concentration 300 ppb. The third set for fruits treated with a low concentration 150 ppb. The fourth and the fifth set for untreated (control) fruits were immersed in distilled water for 1 minute. Each set was duplicated for storage at room and the other in cold storage. Fruits packed in boxes (5% ventilations) with newspaper.

2.2.2. Analysis of quality parameters

- **Fruits weight loss (%):** 20 fruits were used for each treatment, by tracking weight change from interval (zero days) and every four days by a digital balance (Analytical Digital Balance Single Pan). The result was calculated as a percent (%) through using this equation [16]. % Weight= ((initial weight – final weight) / initial weight) *100%.
- **Firmness measurement (N):** Two fruits per replicate for each treatment were used to measure firmness using a digital penetrometer (Lutron FR -5120, QA Supplies LLC, Norfolk, VA, USA) with 4 mm plunger. Two readings were carried out on opposite sides along fruit equatorial region, and the results were expressed in Newton (N).
- **Total Soluble Solid (◦Brix):** Total soluble solids of fruits were measured using a digital refractometer (Milwaukee MA871 model, NC, USA). °Brix content was taken for three fruits per replicate. The results were expressed in degrees °Brix.
- **Titratable Acidity (TA):** The TA, recalculated per citric acid content, by titrating 10 ml of sample of frozen tissue, which had been macerated in 25 ml of distilled water using polytron (Kinematica TM, Luzern, Switzer-land) and by titration to pH 8.2 with 0.1N NaOH using an automatic titrator (716 DMS Titrino, Metrohm,Herisau, Switzerland).
- **Ripening Index (TSS/TA):** The ripening ratio was calculated as the ratio of measured TSS to TA of guava fruit juice as described by [16] using the following formula: **Ripening index** = (measured TSS/ measured TA)
- **Fruit color development:** Three fruits per replicate used for measure color development on guava fruits, using colorimeter device Hunter-scale value (L, a*, b*, hue, and chroma) scale (KONICA MINOLTA) for tracking develop in color of guava fruits.
    a. L-scale: indicated brightness.
    b. a-scale: indicated develop color of fruits from green to red color.
    c. b-scale: indicated develop color of fruits from yellow to blue color.
    d. hue: expresses the color changes of the guava fruits.
    e. Chroma index: analyzes the color value of the guava fruits.

2.3. Data collection and statistical analysis:

A factorial experiment based on a complete randomized design with three replicates for each treatment. The collected data were statistically analyzed using analysis of variance (ANOVA) at $P \leq 0.05$ with Statistic version 10 (Stat Soft, Poland). The student-Newman- Keuls (SNK) range test was used for evaluating the difference in means at 5% probability. Figures were plotted using Sigma Plot version 8.0 (Systat, Chicago, IL, USA).

3. RESULTS AND DISCUSSION

The effect of mcp-1 as a postharvest treatment had a significant influence on the quality and shelf life of guava fruits at low and high storage temperatures compared with untreated (control) fruits. the interaction effect of treated fruits with mcp-1 stored at low temperature had a significant ($p<0.05$) effect on prolong shelf life up to 24 days compared to fruit stored at high temperature up to 12 days. in addition, fruits treated with the highest concentration of mcp-1 (600 ppb) and stored at high temperature showed a significant ($p < 0.05$) effect on preserved quality and prolong shelf life of fruits compared to untreated (control) fruits at low storage temperature (Table 1, appendix).

3.1. Weight loss.

The results showed gradual increase in percent of weight loss in all treatments at both storage temperature (Figure1). Otherwise, all fruits treated with different concentration of MCP-1 showed a significant ($P<0.05$) reduced percent of weight loss compared with untreated (control) fruits. Particularly for fruits treated with 600 ppb of MCP-1 had significantly reduce percent of weight loss compared with other treatments at the end of storage (Figure1). The interaction e□ects of storage temperature, MCP-1, and storage time were significant on fruit weight loss, as 600ppb of MCP-1 combined with room temperature (20°C) significantly maintained fruit weight, and this e□ect was not significantly different when uncoated fruits were kept at (6 °C) (Figure1). The reduction on weight of fruits might be due to evaporation and transpiration processes during ripening process [17]; as shown in the current study untreated (control) fruits recorded a highest percent of weight loss, and that refer to higher rates of respiration and transpiration [17]. Otherwise, the retention of higher fruit weight due to application of 1- MCP was due to their stimulatory effect on fruit metabolism. These could be probably due to the reduced or delayed fruit respiration in 1-MCP treated fruits through reduced the percent of water losses. These results approved with [18] in nectarine fruits.

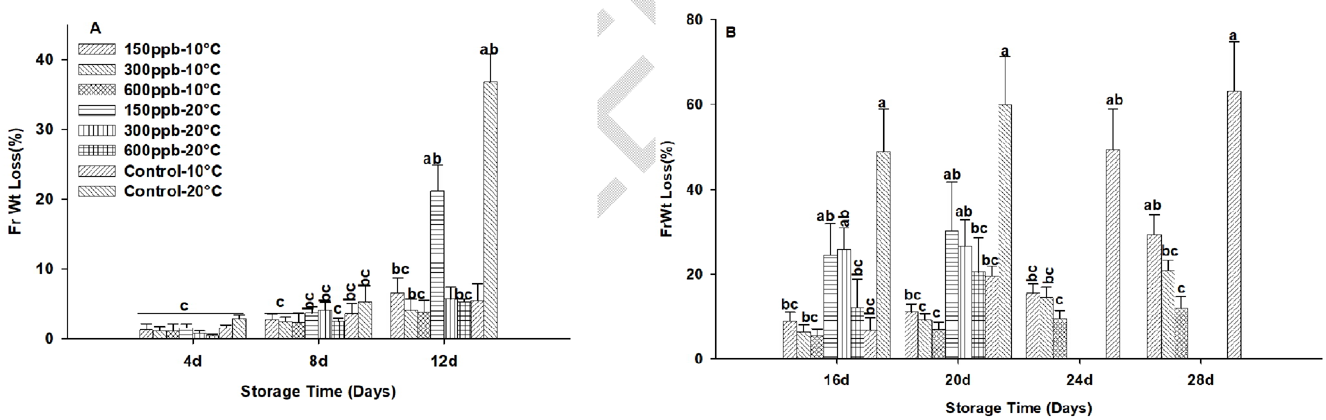

Figure1 (A and B): Effect of different concentration of MCP-1 (150, 300 and 600pbb) on the fruit weight loss trait of guava fruits during storage at low temperature (6°C) and high temperature (21°C) . Each value represents the mean of three biological replicates (± standard division) . The means followed by the same letter are significantly different (SNK test, $P \leq 0.05$).

3.2. Firmness.

Fruit firmness is one of the most important indicators of fruit quality. The results showed that fruit firmness gradually decreased in all treatment (Figure2). Generally, fruits treated with different concentrations of MCP-1 significantly preserved fruit firmness compared with untreated (control) fruits at both storage temperature (Figure2). On the other hand, fruits treated with high concentration of MCP-1 (600pbb) and kept at room temperature (20°C) preserved fruit firmness more than the untreated (control) fruits at cold temperature (6°C) Figure(2). The current study indicated that MCP-1 at different concentration was preserved firmness of fruit at both storage temperature, it's probably associated with reduction in the activity of pectinolytic enzymes induced by smaller ethylene action [19]. Similar results were observed in apple [20], banana [21], and papaya [22].

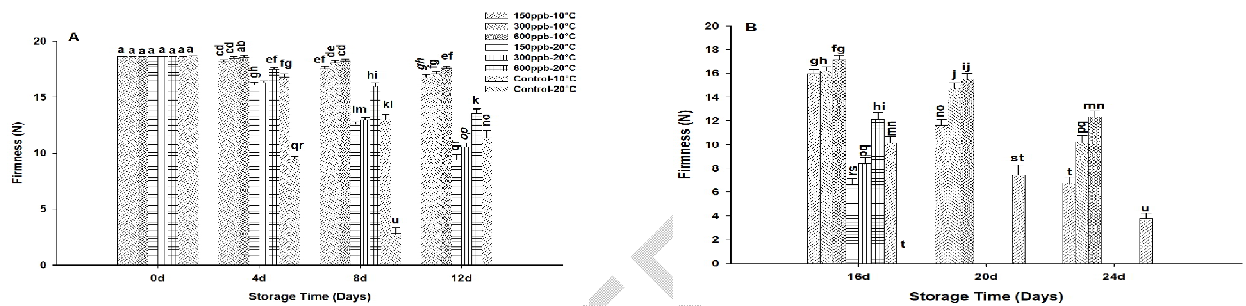

Figure2 (A and B): Effect of different concentration of MCP-1 (150, 300 and 600pbb) on the firmness (N) of guava fruits during storage at low temperature (6°C) and high temperature (21°C) . Each value represents the mean of three biological replicates (± standard division) . The means followed by the same letter are significantly different (SNK test, $P \leq 0.05$)

3.3. Total soluble solid (°Brix).

The current study shows gradual increase in the TSS with different treatment and at different days storage (**FIGURE**3). However, no significant difference between treatment after 4th days from storage. While, after 8 days until the termination of experiments fruits treated with highest concentration 600pbb of MCP-1 showed lower TSS content compared within other treatments (**Figure**3). Furthermore, no significant ($P \leq 0.05$) differences were found between fruits treated with 600 pbb of MCP-1 kept at room temperature (21°C) and uncoated (control) fruits at cold storage (10°C). The increase in TSS during storage may be due to breakdown of complex organic metabolites into simple molecules or hydrolysis of starch into sugar [23]. Similar reports were also given by [24] in banana fruits. Highest value of TSS was also reported by [25] in yellow pitahaya fruits. Whereas the lower TSS due to treatment of fruits with 1-MCP, is working on delays fruit ripening through inhibitor ethylene production. In addition, the amount of sugars usually increases along with fruit ripening through biosynthesis processes or degradation of polysaccharides [21].

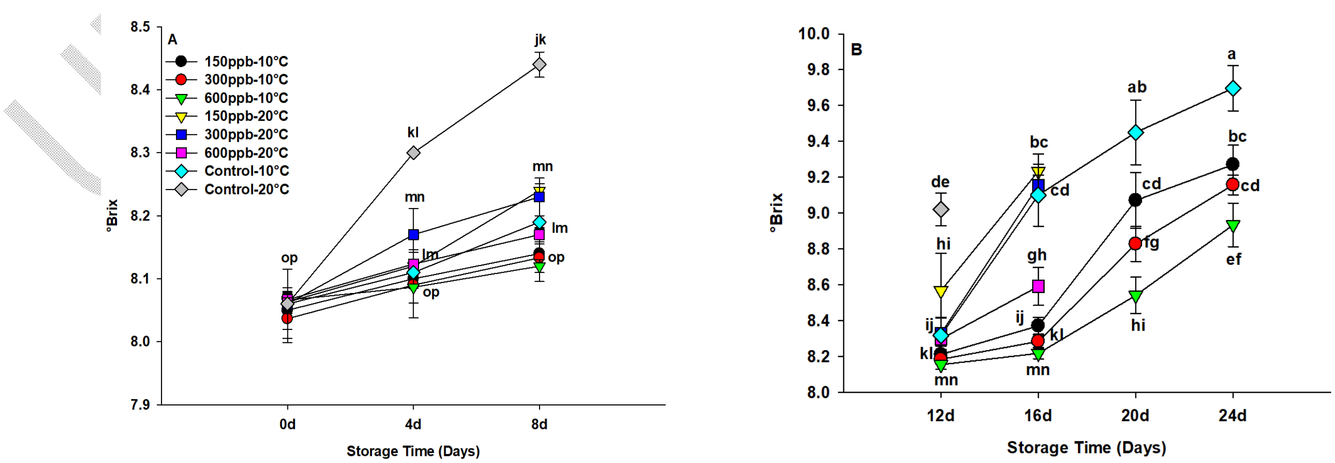

Figure3 (A and B): Effect of different concentration of MCP-1 (150, 300 and 600pbb) on the Brix content of guava fruits during storage at low temperature (6°C) and high temperature (21°C) . Each value represents the mean of three biological replicates (± standard division) . The means followed by the same letter are significantly different (SNK test, P ≤ 0.05)

3.4. Titratable Acidity (TA):

The current study showed a gradual and progressive decrease in acidity at treatments during both storage temperature. The results showed maximum percent of TA was observed in fruits treated with 600ppb MCP-1 at cold storage. Whereas the minimum (0.42%) was recorded in untreated (control) fruits at high temperature storage (Figure4). Among the different of MCP-1 concentration 150, 300, and 600ppb was used almost equally effective in maintaining higher acidity during room temperature storage compared to untreated fruits at cold storage. The progressive decline might be due to utilization of acid in metabolism (reference). Postharvest application of MCP-1 delayed the decline in concentrations of TA, these delayed reductions in TA levels are attributed to the delayed ripening process in treated fruits with MCP-1 [26]. A similar results pattern was found in Pear fruit [15].

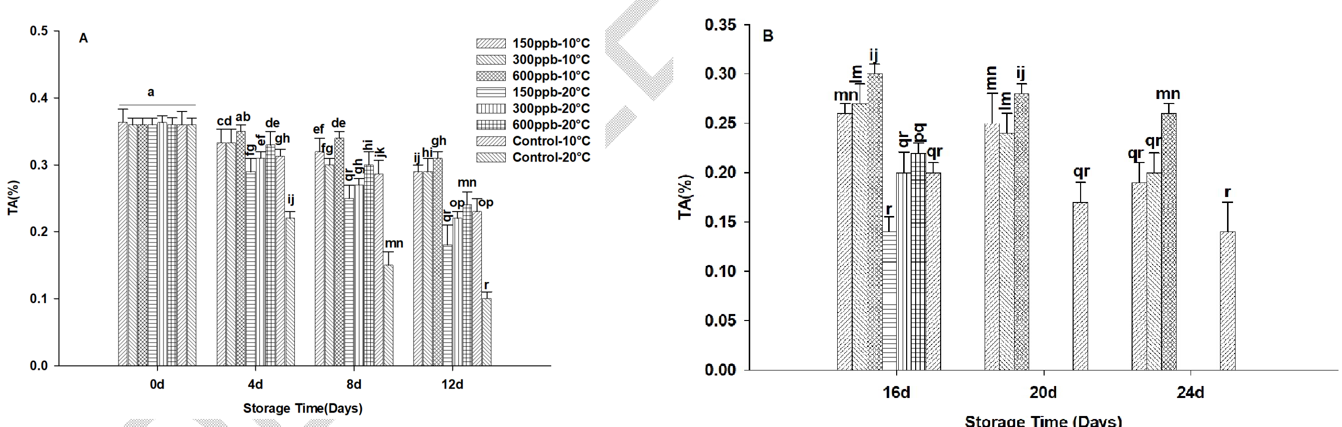

Figure 4 (A and B): Effect of different concentration of mcp-1 (150, 300 and 600pbb) on the titratable acidity of guava fruits during storage at low temperature (6°c) and high temperature (21°c) . each value represents the mean of three biological replicates (± standard division) . the means followed by the same letter are significantly different (snk test, p ≤ 0.05)

3.5. Ripening Index.

During the storage time, the ripening index increased with increase storage time in all treated and untreated fruits (Figure. 5). However, untreated (control) fruits, TSS: TA ratio had a significant (p≤0.05) sharp increase from 4 days of storage till the deterioration of fruits. On the other hand, different concentration of MCP-1 had minor changes in TSS: TA ratio after 8 days of storage till the deterioration of the fruit at both storage temperature (Figure. 5). No significant difference was found between fruits treated with 600pbb of MCP-1 kept at room temperature (21°C) and uncoated (control) fruits at cold storage(10°C) (Figure5). The result indicated, treated fruits with different concentration of MCP-1 take more time to reach full maturity. In addition, MCP-1 as postharvest treatments found to reduce the ethylene rate production, thus delaying the utilization of organic acids, and delay ripening fruit [21].

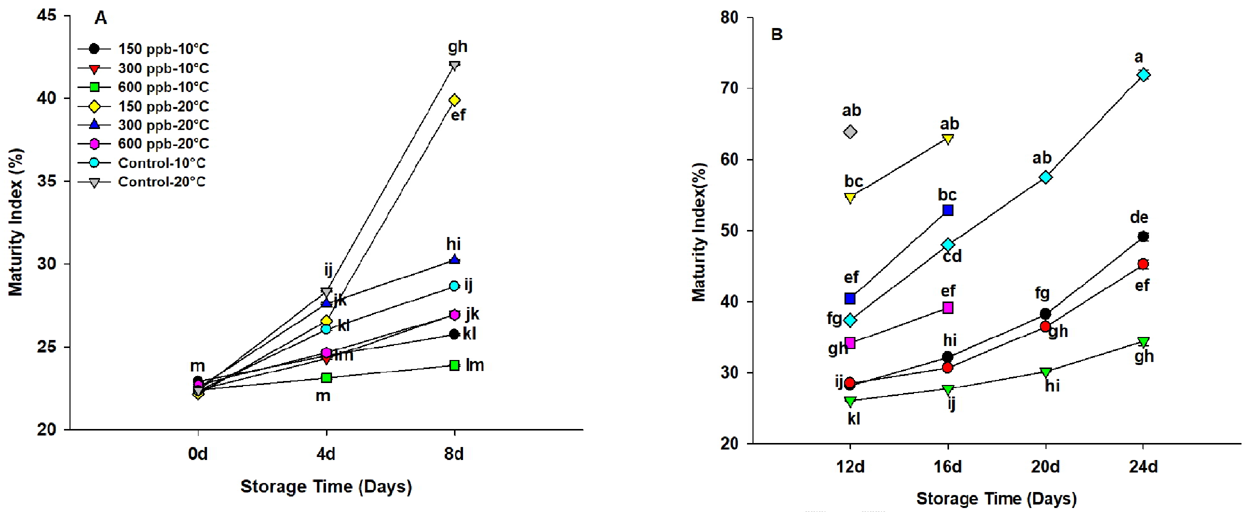

Figure 5 (A and B): Effect of different concentration of MCP-1 (150, 300 and 600pbb) on the maturity index (%) of guava fruits during storage at low temperature (6°C) and high temperature (21°C (. Each value represents the mean of three biological replicates (± standard division (. The means followed by the same letter are significantly different (SNK test, P ≤ 0.05).

3.6. Fruits Color Development:

The development of fruits color was primarily evaluated by using hunter scale value (l*, a*, b*, hua, and chrom) scale. h-angle, which indicate the brightness, color saturation and the hue angle of the peel, respectively. as shown in (Figure6, d). the l* value gradually increased with fruit ripening for the untreated (fruits) control (Figure6, a). whereas no significant difference was observed between fruits treated with highest concentration (600ppb) of mcp-1 at room storage with untreated (control) fruits at cold storage (Figure6, a). the chroma value of fruit increased with fruit ripening, with a high significant difference was observed between the different concentration of mcp-1 at both storage conditions (Figure6, e). while the h-angle gradually decreased with fruit ripening in all treatments with a significant difference between fruits. accelerated in develop of fruits color refer to loss of green skin color, due to chlorophyll molecule breakdown by the chlorophyll's activity [19]. The increase in the activity of this enzyme is generally associated with ethylene production during fruit ripening [27]. the product binds to the ethylene binding site in cells, inhibiting ethylene action on the physiologic processes of ripening [21]. therefore, loss of green color resulting from the normal ripening process was delayed by the application of 1-mcp. green color retention in fruits treated with 1-mcp has also been observed in chinese pear [28], bananas [21], and avocado [27].

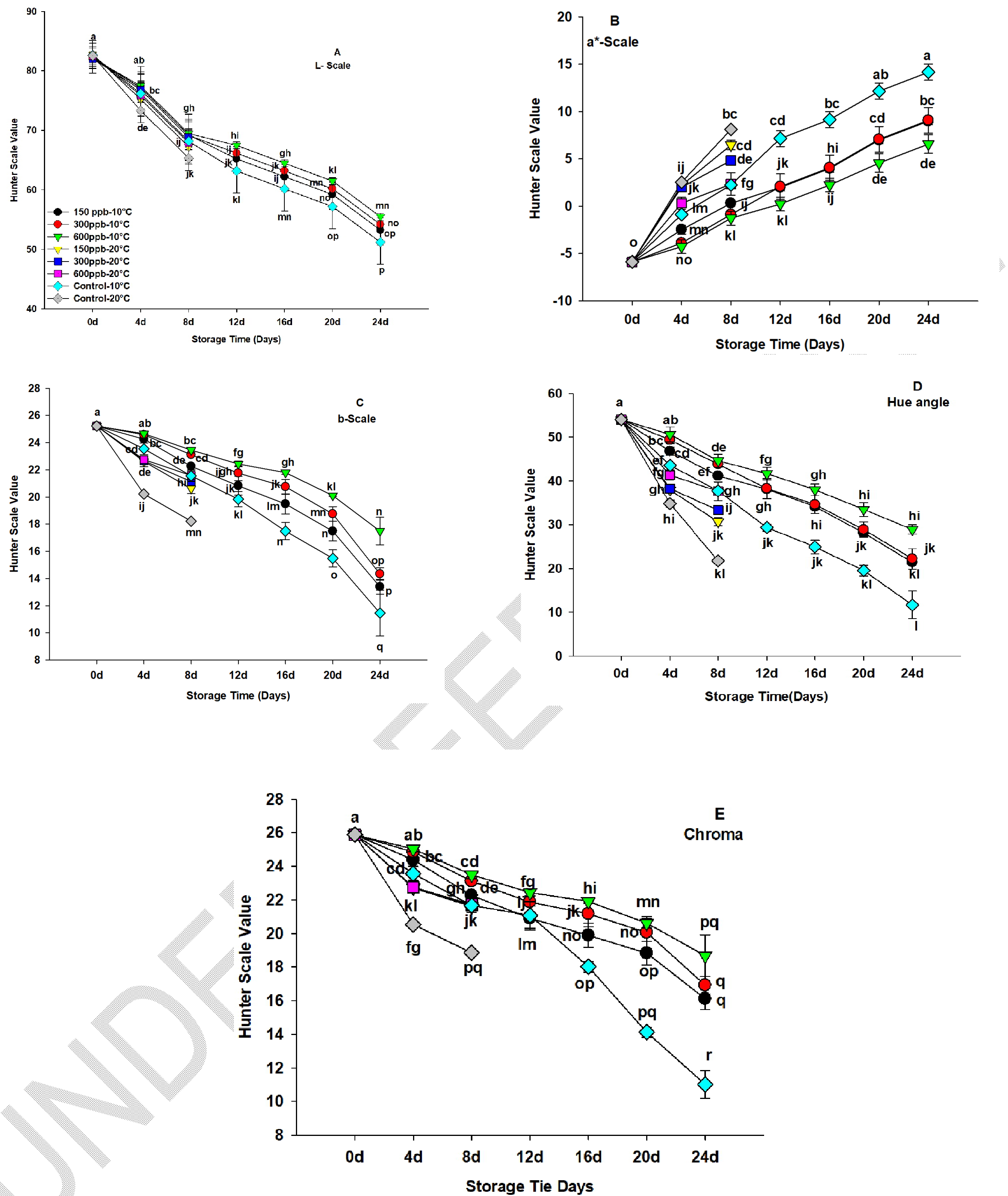

Figure 6 (A and B): Effect of different concentration of MCP-1 (150, 300 and 600pbb) on the color development (L, a, b, hue and chroma) scale of guava fruits during storage at low temperature (6°C) and high temperature (21°C) . Each value represents the mean of three biological replicates (± standard division) . The means followed by the same letter are significantly different (SNK test, P ≤ 0.05)

4. CONCLUSION

MCP-1 as postharvest treatment was preserved quality of fruits and prolong shelf life of guava fruits as compared with untreated (control) fruits. in addition, the overall fruit quality was maintained up to 24 days at cold (6°c) storage, and up to 20 days at room (20°c) storage as compared with untreated fruits only for 12 days. mcp-1 as a postharvest treatment then stored at the room storage condition had no significant difference in fruit firmness and acceptable organoleptic quality with untreated fruits stored at low-temperature conditions. these results indicated that mcp-1 to be effective, highest dose levels of 1-mcp (600 pbb) were best to maintain the quality of guava fruits during storage.

CONSENT (WHERE EVER APPLICABLE)

"All authors declare that 'written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal."

REFERENCES

1- Arévalo-Marín, E., Casas, A., Landrum, L., Shock, M. P., Alvarado-Sizzo, H., Ruiz-Sanchez, E., Clement, C. R. 2021. **The Taming of Psidium guajava: Natural and Cultural History of a Neotropical Fruit**. Frontiers. Plant. Sci. 12. DOI:10.3389/fpls.2021.714763.

2- Ministry of Agriculture. 2021. Palestinian Ministry of Agricultural.

3- Yadav, A., Kumar, N., Upadhyay, A., Fawole, O. A., Mahawar, M. K., Jalgaonkar, K., Chandran, D., Rajalingam, S., Zengin, G., Kumar, M., & Mekhemar, M. 2022. **Recent Advances in Novel Packaging Technologies for Shelf-Life Extension of Guava Fruits for Retaining Health Benefits for Longer Duration.** Plants. 11 (4): 547. DOI:10.3390/plants1104054.

4- Maduwanthi, S.D.T; Marapana, R.A.U.J. 2019. **Induced Ripening Agents and their Effect on Fruit Quality of Banana**. International. J. Food. Sci. 1–8. DOI:10.1155/2019/2520179.

5- Al-Dairi, M.; Pathare, P.B.; Al-Yahyai, R. 2021. **Effect of postharvest transport and storage on color and firmness quality of tomato**. J. Horti. 7, (7): 163. DOI:10.3390/horticulturae7070163.

6- Daraghmah, F. S., Qubbaj, T. 2022. **Impact of gum arabic and cactus mucilage as potential coating substances combined with calcium chloride treatment on tomato (Solanum lycopersicum L.) fruit quality attributes under ambient storage conditions**. Canadian. J. Plant. Sci. 102 (2): 375–384. DOI:10.1139/CJPS-2021-0164.

7- Huan, C.; Zhang, J.; Jia, Y.; Li, S.; Jiang, T.; Shen, S.; Zheng, X. 2021. **Effect of 1-Methylcyclopropene Treatment on Quality, Volatile Production and Ethanol Metabolism in Kiwifruit during Storage at Room Temperature**. J. Sci. Horti. 265: 109-266. DOI:10.3390/horticulturae7100381.

8- Xie, G., Feng, Y., Chen, Y., & Zhang, M. 2020. **Effects of 1-Methylcyclopropene (1-MCP) and Ethylene on Postharvest Lignification of Common Beans (Phaseolus vulgaris L)**. 5, (5): 8659–8666). DOI:10.1021/acsomega.0c00151.

9- Cao, S. F.; Zheng, Y. H.; Wang, K. T.; Rui, H. J.; Shang H. T.; Tang, S.S. 2010. **The Effects of 1-Methylcyclopropene on Chilling and Cell Wall Metabolism in Loquat Fruit**. J. Horti. Sci. Biotech. 85(2): 147-153. DOI:10.1080/14620316.2010.11512646.

10- Chen, Y. H.; Sun, J.Z.; Lin, H.T.; Hung, Y.C.; Zhang, S.; Lin, Y.N.; Lin, T. 2016. **Paper-Based 1-Mcp Treatment Suppresses Cell Wall Metabolism and Delays Softening of Pears During Storage**. J. Sci. Food. Agri. 97(8): 2547-2552. DOI:10.1002/jsfa.8072.

11- Li, J.; Han, Y.; Hu, M.; Jin, M.; Rao, J. 2018. **Oxalic Acid and 1-Methyl-Cyclopropene Alleviate Chilling Injury of Kiwifruit during Cold Storage**. Postharvest. Bio. Techno. 137: 134-141. DOI:10.1016/j.postharvbio.2017.11.021.

12- Lin, Y. H.; Lin, Y.Y.; Lin, H.T.; Lin, M.S.; Li, H.; Yuan, F.; Chen, Y. H.; Xiao, J.B. 2018. **Effects of Paper Containing 1-Mcp Postharvest Treatment on the Disassembly of Cell Wall Polysaccharides and Softening in Plum Fruit during Storage.** Food. Chem. 264: 1-8. DOI: 10.1016/j.foodchem.2018.05.031.

13- Yihui, G., J. Song, L. Du, M. Vinqvist, L. C. Palmer, S. Fillmore, X. Q. Pang, and Z. Q. Zhang. 2018. **Characterization of laccase from apple fruit during postharvest storage and its response to diphenylamine and 1-methylcyclopropene treatments**. Food. Chem. 253: 314-321. DOI:10.1016/j.foodchem.2018.01.142

14- Maletsika, P.A.; Georgoudaki, T.A.; Nanos, G.D. 2020. **Cold Storage Temperature and 1-MCP Postharvest Treatment on 'Starking Delicious' Apple Quality.** Inter. J. Agri. Enviro. Sci. 7(3): 64–70. DOI:10.14445/23942568/IJAES-V7I3P108.

15- Nguyen, L. L. P.; Pham, T. T.; Syium, Z. H.; Zsom-Muha, V.; Baranyai, L.; Zsom, T.; Hitka, G. 2022. **Delay of 1-MCP Treatment on Post-harvest Quality of 'Bosc Kobak' Pear**. Horti. 8(2): 89. DOI:10.3390/horticulturae8020089.

16- Sati, F., Qubbaj, T. 2021**. Impact of gum arabic and cactus mucilage as potential coating substances combined with calcium chloride treatment on tomato (*Solanum Lycopersicum l.*) fruit quality attributes under ambient storage conditions**. Canadian. J. Plant. Sci. 0164. DOI:10.1139/cjps-2021-0164.

17- Paul, V.; Pandey, R. 2011. **Role of Internal Atmosphere on Fruit Ripening and Storability**. J. Food Sci. Techno. 51 (7): 1223–1250. DOI: 10.1007%2Fs13197-011-0583-x

18- Ullah, S., Z. Singh, A. S. Khan, S. A. K. U. Khan, K. Razzaq, and A. D. Payne. 2016. **Postharvest application of 1-MCP and ethylene influences fruit softening and quality of 'Arctic Pride' nectarine at ambient conditions.** Australian. J. Crop. Sci. 10 (9): 1257–1265. DOI:10.21475/ajcs.2016.10.09.p7648.

19- Bassetto, E.; Jacomino, A.P.; Pinheiro, A.L. 2005. **Conservation of "Pedro Sato" Guavas under Treatment with 1-Methylcyclopropene**. Pesquisa Agro. Brasília. 40(5): 433–440. DOI:10.1590/S0100-204X2005000500002.

20- Wasala, W. M. C. B., Benaragama, C. K., Kumara, G. D. K., Sarananda, K. H., Dissanayake, C. A. K. 2021. Application of 1-Methylcyclopropene (1-MCP) for Delaying the Ripening of Banana: A Review. Asian. Research. J. Agri. 44–56. DOI:10.9734/ARJA/2021/v14i130118.

21- Satekge, T. K., and L.S. Magwaza. 2020. **The Combined Effect of 1-methylcyclopropene (1-MCP) and ethylene on green-life and postharvest quality of banana fruit.** Inter. J. Fruit. Sci. 20: 1539–1551. DOI:10.1080/15538362.2020.1818162.

22- Manenoi, A., Bayogan, E. R. V., Thumdee, S., Paull, R. E. 2007. **Utility of 1-methylcyclopropene as a papaya postharvest treatment**. Postharvest. Bio. Tech. 44 (1): 55–62. DOI:10.1016/j.postharvbio.2006.11.005

23- Mahajan, B.V.C.; Gagandeep, S. 2008. **Effect of 1-Methylcyclopropene (1-MCP) on Storage Life and Quality of Winter Guava**. J. Food. Sci. Techno. 45(6): 537-539.

24- Li, X., Xiong, T., Zhu, Q., Zhou, Y., Lei, Q., Lu, H., Chen, W., Li, X., Zhu, X. 2023. **Combination of 1-MCP and modified atmosphere packaging (MAP) maintains banana fruit quality under high temperature storage by improving antioxidant system and cell wall structure.** Postharvest. Bio.Tech.198: 112-265. DOI:10.1016/j.postharvbio.2023.112265

25- Deaquiz, Y.A.; Álvarez-Herrera, J.; Fischer, G. 2014. **Ethylene and 1-MCP Affect the Postharvest Behavior of Yellow Pitahaya Fruits (*Selenicereus Megalanthus Haw*).** Argo. Columbiana. 32(1):44-51. DOI:10.15446/agron.colomb.v32n1.41950.

26- Hong, K.Q.; He, Q.G.; Xu, H.B.; Xie, J. H.; Hu, H.G.; Gu, H.; Gong, D.Q. 2013. **Effects of 1-MCP on Oxidative Parameters and Quality in 'Pearl' Guava (*Psidium guajava L.*) Fruit**. J. Horti. Sci. Bio. 88: 117-122. DOI:10.1080/14620316.2013.11512944.

27- Shikwambana, K., Mathaba, N., & Mafeo, T. 2023. **The physiological effect of fruit maturity and 1-methylcyclopropene on 'Hass' avocado fruit exocarp colour, and chilling injury during ripening**. J. Horti. Postharvest. Res. DOI:10.22077/jhpr.2022.5538.1287

28- Wei, J., Cheng, Y., Feng, Y., Qi, X., He, J., & Guan, J. 2019. **Different response to 1-methylcyclopropene in two cultivars of Chinese pear fruit with contrasting softening characteristics.** J. Applied. Botany. Food. Quality. 92. DOI:10.5073/JABFQ.2019.092.019

Appendix:

Table (1). Variance analysis of the effect of MCP-1 and storage temperature on quality attributes of guava fruits.

S.O.V	df	Mean Square (MS)									
		Weight	Firmness	a*scale	l*scale	b*scale	Hue	Chrom	TA	TSS	Ripening index
Temperature (T)	1	3821.8*	1715.7*	180.33*	51118.4*	5163.6*	1574.3*	5975.1*	0.45677*	323.70*	3050.07*
Coating (C)	3	4025.8*	285.23*	72.087*	24.0*	26.96*	332.3*	7.44*	0.02941*	1.918*	477.20*
Storage time (D)	6	1715.7*	655.27*	313.85*	1464.7*	1427.28*	6684.0*	1336.48*	0.23192*	72.281*	1220.48*
T × C	3	802.4	4.27*	32.636*	7.4	8.72*	94.70*	3.46*	0.00103*	5.590*	698.99*
T × D	6	10004.3*	94.31*	211.424*	6091.8*	517.04*	1170.9*	603.70*	0.04731*	115.59*	4050.82*
C × D	18	223.09*	16.89*	3.526*	1.3	1.31*	25.80*	1.53*	0.00321*	4.008*	216.37*
T × C × D	18	1069.6*	14.58*	4.689*	2.6	2.56*	36.50*	0.59*	0.00224*	5.170*	328.56*
ERROR	110	241.71	0.46	1.601	3.3	0.16	10.90	0.14	0.00040	0.005	21.28
C.V (%)		109.2	5.78	93.86	3.64	2.63	12.10	2.33	8.73	1.03	16.24

ns not significant, and * significant at 5% levels.