INFLUENCE OF CITRIC ACID, GINGER EXTRACT AND STORAGE PERIOD ON FRUIT QUALITY OF LOCAL ORANGE (Citrus sinensis L. Osbeck)

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ABSTRACT
This study was carried out on fruit of local orange (Citrus sinensis L. Osbeck) grown at private orchard Diyala governorate / Iraq, to study the effect of dipped fruits for 10 min in (0, 1, 2, 3% citric acid, 5 and 10% ginger) on fruit quality of orange during 65- and 105-days cold storage at 5+1℃ with 85-90% RH. Dipping fruits in citric acid solution reduced fruit's weight loss and decay. Ginger extract at 5 and 10% significantly reserved acidity, total sugar and sugar/acid ratio, also caused a reduction in fruit weight loss and fruit decay. There was a significant decreases in fruits peel carotene and an increases in vitamin C, when fruits were treated with 5% ginger extract. Prolonging storage period from 65 to 105day significantly increased fruit total soluble solids, weight loss, total sugar, and fruit peel carotene but, reduced vitamin C and total acidity. The interaction between dip treatments and storage period had a significantly positive effect on the quality feature of fruit orange.

Keywords: orange, organic acid, plant extract. postharvest.
INTRODUCTION

Orange (Citrus sinensis L. Osbeck) is among the most important evergreen fruit trees belonging to the genus Citrus of the Rutaceae family, it is a winter fruit and is considered the most traded horticultural product in the world (26). Citrus is mainly cultivated in the subtropical and tropical regions of the world. The success of growing citrus in different climatic conditions is due to their adaptation to a wide range of environmental conditions that range from warm and humid tropical climates to areas with warm subtropical climates to cold regions (11 and 27). The production and consumption of oranges increase every year in Iraq. Citrus is non-climacteric fruit and had a greater shelf life, fruits during the maturity and ripening stage the composition of ethylene and respiration are not varied as in climacteric fruits. Citrus fruits may have some post-harvest physiological problems if not handled and stored appropriately. Weight loss and some physiological disorders are the major problems of citrus which not only cause quantitative losses but it also results in qualitative problems such as softening, shriveling (13). Citric acid is a weak organic acid found in citrus fruits, it is often considered a safe, thin edible organic coating helped to improve the fruit quality, and is consumable without any side effects on health (32). Citric acid inhibits the growth and activity of bacteria and fungi in fruits and vegetables, also induces the improvement of disease resistance in fruits (24). Citric acid 2% and low temperature inhibited the microorganisms from blueberries surface during 6 weeks of refrigerated storage, maintained significantly higher value total soluble solids than control fruit, while the fruit weight loss increased during cold storage (25). Yang et al (33) reported that treated fruits with 10 mg. L⁻¹ citric acid reduced postharvest decay and effectively maintain the texture, flavor, and nutrition quality of peach fruit. Ginger extracts can inhibit the activity and growth of various bacteria and fungi (4). Gingerol, zingiberol, paradol, bisabolene, and zingiberine are phenolic compounds produce by ginger (22). These compounds are responsible for both the anti-fungal and antibacterial activity of ginger (17). Herbal extract (ginger, garlic, lemongrass, and chili) at 10% were more effective to maintain the quality attributes of china lime fruits, and 10% ginger significantly have higher values of total sugar, acidity, TSS, juice content, and fruit weight loss after garlic in other treatment (28). Acharya et al (3) reported that weight loss, juice percentage, and TSS of the fruit were increased compared with control fruits coincided with the progress of the storage period. Postharvest storability of Valencia oranges is limited to about 3 months and was noted to highly influence by pathogenic decay and weight loss (7). This experiments was conducted to study some qualitative characteristics and control the post-harvest losses of local oranges during cold storage, also to study the role of the postharvest treatment (citric acid and ginger) on the quality of the fruit and it is storage ability.

MATERIALS AND METHODS

Fully mature, medium-sized fruits were manually harvested from trees during early morning from a private orchard in Diyala governorate, Iraq, and were transferred to the Central Laboratory, College of Agricultural Engineering Sciences, University of Duhok. Sound fruits were selected and divided into two groups for each storage period (65 and 105 days). Fruits of each group were dipped for 10 min in citric acid and ginger extract solution (control, 1, 2, 3 % citric acid, and 5, 10 % ginger), air-dried and put in perforated polyethylene bags, the bags were tied, and stored in cold storage at 5+1°C and 85- 90 RH. After each period of storage (65 and 105 days). The bags were opened for analysis. The experiment was laid out in Complete Randomized Design (CRD) including two factors citric acid, ginger, and storage period (6×2), with three replicates and 6 fruits for each replicates in each storage period. The results were analyzed using analysis of variance and the means were compared using Duncan Test at 0.05 probability Duncan(9). The parameters that were taken during the experiment as given below:

1- Total soluble solid (TSS %): The total soluble solid was determined by Hand Refractometer (1).

2- Ascorbic Acid (mg. 100 ml⁻¹ juice): The ascorbic acid (V.C) in fruit juice was measured
with the titration method by using 2,6-Dichlorophenol indophenols recommended (1).

3- Juice percentage (%): The fruit juice (%) was calculated by knowing the weight of juice divided by the weight of the fruit for each replication (18).

4- Fruit weight loss (%): The initial fruit weights were determined before storage, then the weight of the same fruits recorded after each storage period. The weight loss (%) was calculated depending on El-Badawy (10) recommendation.

5- Decay (%): The percentages of discarded fruits were calculated based on Abd-EI-Ghany et al (2).

RESULTS AND DISCUSSION

Total soluble solids (TSS %): The data clarified that the fruit TSS of untreated fruit was highest significantly differences with a dip in 2% citric acid. Jasim (15) revealed that citric acid 0.5% resulted in significantly the lowest TSS of Valencia orange fruits during the storage at 5°C. Increasing TSS values in control fruits might be due to concentrating fruit juice because of higher water loss. TSS (%) was increased significantly when the storage period prolonged from 65 to 105 days. Eman et al (12) stated that the TSS content of Guava fruits was increased with increasing the storage period. These results could be due to the degradation of complex insoluble compounds, like starch, to simple soluble compounds, like sugars, which are the major TSS components. (14). The interaction demonstrated that 3% citric acid and 105 days were noticed significantly the highest TSS in fruit compared with interaction treatments of 2 and 3% citric acid at the 65 days storage period (Table 1).

| Treatments         | Storage period (day) | Treatments effect |
|--------------------|----------------------|-------------------|
|                    | 65                   | 105               |                     |
| Control            | 12.30 a              | 12.53 a           | 12.42 a            |
| Citric acid 1%     | 11.97 a              | 12.43 a           | 12.20 ab           |
| Citric acid 2%     | 10.87 b              | 12.37 a           | 11.62 b            |
| Citric acid 3%     | 11.00 b              | 12.60 a           | 11.80 ab           |
| Ginger 5%          | 11.97 a              | 12.47 a           | 12.22 ab           |
| Ginger 10%         | 12.10 a              | 12.23 a           | 12.17 ab           |
| Periods effect     | 11.70 b              | 12.44 a           |                     |

Means followed by the same letters did not differ significantly according to Duncan's test at 0.05 level

Vitamin C (mg.100ml⁻¹ juice): Ginger had a positive effect in fruit juice vitamin C. The maximum vitamin C represented in fruit dipped in 5% ginger which was significantly higher than other treatments except for 10% ginger, but the lowest vitamin C was founded in non-dipped fruit (Table 2). Ayranci and Tunc (6) found a lowest of ascorbic acidity loss of fruit guava with (citric acid 2%), and Ayranci and Tunc (5) reported that inclusion of citric acid in the coating formulation as an antioxidant which lowered the ascorbic acid loss of fruits. When prolonging the storage period from 65 to 105 days induced a significant reduction in fruit juice vitamin C, so it is clear that stored fruit for 65 days caused significantly the highest vitamin C. The possible reason for ascorbic acid losses during storage might be attributed to the rapid conversion of L-ascorbic acid into dihydro-ascorbic acid in the presence of L-ascorbic acid oxidase (14). Fruits that were dipped in 5% ginger and 65 days storage obtained significantly the largest value of vitamin C compared with all other interaction treatments. The minimum value of vitamin C was observed from the interaction between 2% citric acid and 105 days storage period.
Table 2. Effect of citric acid, ginger, and storage periods and their interactions on fruit vitamin C (mg.100ml⁻¹ juice) of orang stored at 5±1 °C

| Treatments      | Storage period (day) | Treatments effect |
|-----------------|----------------------|-------------------|
|                 | 65                   | 105               |                    |
| Control         | 50.33 b-e            | 46.87 f           | 48.60 c           |
| Citric acid 1%  | 52.06 bc             | 48.74 d-f         | 50.40 b           |
| Citric acid 2%  | 50.69 b-d            | 46.65 f           | 48.67 c           |
| Citric acid 3%  | 52.42 b              | 48.17 e           | 50.29 b           |
| Ginger 5%       | 54.65 a              | 49.90 c-e         | 52.27 a           |
| Ginger 10%      | 52.42 b              | 49.97 c-e         | 51.19 ab          |
| Periods effect  | 52.09 a              | 48.38 b           |                    |

Means followed by the same letters did not differ significantly according to Duncan’s test at 0.05 level.

Fruit juice (%): Dipped fruit in 10% ginger significantly caused an increase in fruit juice compared with other treatments, while the lowest percentage of fruit juice resulted from the fruit that was dipped in 2% citric acid (Table 3). Treatments of ginger extraction and citric acids that clearly effective in conferring a physical barrier to moisture loss and therefore retarding dehydration and fruit shriveling which leads to fruits retaining a high percentage of juice (30). The results in

Table 3. Effect of citric acid, ginger, and storage periods and their interactions on fruit juice (% of orang stored at 5±1 °C

| Treatments      | Storage period (day) | Treatments effect |
|-----------------|----------------------|-------------------|
|                 | 65                   | 105               |                    |
| Control         | 52.08 a-c            | 51.46 bc          | 51.77 b           |
| Citric acid 1%  | 52.16 a-c            | 51.43 bc          | 51.80 b           |
| Citric acid 2%  | 52.06 a-c            | 49.91 c           | 50.98 b           |
| Citric acid 3%  | 52.51 a-c            | 52.27 a-c         | 52.39 ab          |
| Ginger 5%       | 52.59 a-c            | 50.24 c           | 51.42 b           |
| Ginger 10%      | 53.53 ab             | 54.93 a           | 54.23 a           |
| Periods effect  | 52.4 9a             | 51.71 a           |                    |

Means followed by the same letters did not differ significantly according to Duncan’s test at 0.05 level.

Fruit juice loss (%): Results in Table 4 show that all treatments significantly reduced fruit weight loss (%), the minimum fruit weight loss was from the fruits that dipped in 5% ginger compared with highest fruit weight loss was found from non-dipped fruit. Sowani and Zahng (31) mentioned that the lower weight loss was steadily shown with the fruits treated with citric acid, the fruit weight loss increased significantly as storage prolonged from 65 to 105 days. Highest weight loss of fruits which found in the later storage condition could be associated with a faster metabolism and ripening, which increased cell wall degradation, and highest membrane permeability leading to exposure of cell water for easy evaporation (20). The interaction between treatments concentration and storage periods appeared that the lowest fruit weight loss was observed when the fruit dipped in 5% ginger and stored for 65 days, in comparison with, the maximum fruit weight loss found from the interaction between the untreated fruits and 105 days storage period.
Table 4. Effect of citric acid, ginger, and storage periods and their interactions on fruit weight loss (%) of orange stored at 5+1 °C

| Treatments          | Storage period(day) | Treatments effect |
|---------------------|---------------------|-------------------|
|                     | 65                  | 105               |                     |
| Control             | 4.81 b              | 7.64 a            | 6.22 a              |
| Citric acid 1%      | 1.91 e              | 3.10 d            | 2.51 b              |
| Citric acid 2%      | 1.87 e              | 3.23 cd           | 2.55 b              |
| Citric acid 3%      | 2.09 e              | 3.71 cd           | 2.90 b              |
| Ginger 5%           | 1.78 e              | 3.07 d            | 2.42 b              |
| Ginger 10%          | 1.79 e              | 4.02 bc           | 2.91 b              |
| Periods effect      | 2.38 b              | 4.13 a            |                     |

Means followed by the same letters did not differ significantly according to Duncan’s test at 0.05 level

Decay (%): The decay percentage reduced significantly when the fruit was treated with all dipping treatment as compared with the decay of control fruits (Table 5). Citric acid is an anti-browning agent, which prevents polyphenol oxidase (PPO) activity by suppressing the food pH and binding the Cu in an active site of PPO to form an inactive complex (21). Jiang et al (16), and Zhang et al (35) their results explained that citric acid plus chitosan-treated fruits could retard senescence and reduce MDA accumulation in the fruits, suggesting that the treatments played positive roles in maintaining membrane integrity. As prolonged storage periods from 65 to 105 days caused an increase in fruit decay depending on the progress of the storage period of the fruits but not reached a significant increase. During ripening parenchyma cell walls are extensively modified, altering their mechanical properties, and cell adhesion is significantly reduced as a result of middle lamella dissolution. Cell wall and middle lamella modifications leading to fruit softening result from the action of cell wall modifying enzymes (e.g., polygalacturonase, pectin methylesterase, pectate lyase, galactosidase, cellulase), generally encoded by ripening-related genes (8). The protection of fruit cells from oxidative injury depends on the level of antioxidant enzymes, such as catalase, peroxidase, polyphenol oxidase, and superoxide dismutase which scavenge ROS and prevent harmful effects (22, 33) and these enzymes decreased as the fruits were near the end of storage period. The results revealed in the same Table that the interaction between untreated and 65 or 105 days of storage periods had a significant increase in fruit decay. Generally, the result showed that decay decreased at all dipping concentrations treatments and both storage period interactions.

Table 5. Effect of citric acid, ginger, and storage periods and their interactions on fruit decay (%) of orange stored at 5+1 °C

| Treatments          | Storage period (day) | Treatments effect |
|---------------------|----------------------|-------------------|
|                     | 65                   | 105               |                     |
| Control             | 27.78 ab             | 38.89 a           | 33.34 a             |
| Citric acid 1%      | 5.56 c               | 0.00              | 2.78 b              |
| Citric acid 2%      | 0.00 c               | 11.11 bc          | 5.56 b              |
| Citric acid 3%      | 0.00 c               | 16.67 bc          | 8.34 b              |
| Ginger 5%           | 0.00 c               | 5.56 c            | 2.78 b              |
| Ginger 10%          | 5.56 c               | 5.56 c            | 5.56 b              |
| Periods effect      | 6.48 a               | 12.96 a           |                     |

Means followed by the same letters did not differ significantly according to Duncan’s test at 0.05 level

CONCLUSION

Citric acid and ginger extract were found to be very effective in prolonging the storage period of orange fruits. Treating fruits with citric acid and ginger was effective in preserving most quality properties of fruits during the cold storage period. The ginger had various medicinal properties itself and therefore the present study shows the prospects for utilization of extract as a coating material.

REFERENCES

1. A.O. A. C. .2000. Official Methods of Analysis. 11th Ed. Washington, D.C. Association of Official Analysis Chemist. 1015
2. Abd-Elghany, N. A., S. I. Nasr and H. M. Korkar .2012. Effects of polyolefin film
wrapping and calcium chloride treatments on postharvest quality of "wonderful" pomegranate fruits. J. Hort. Sci. Ornament. Plants. 4 (1): 07-17
3. Acharya, B., B. Joshi, R. Regmi and N. Poudel .2020. Effect of Plant extracts and packaging materials on prolonging shelf life and maintaining quality of mandarin (Citrus reticulate Blanco.). International Journal of Horticulture, Agriculture and Food Science. 42: 2456-8635
4. Akponah, E., I. O. Okoro, M. Ubogu and F. E. Ejuokonemu .2013. Effects of ethanolic extracts of garlic, ginger, and rosemary on the shelf-life of orange juice. Int J Agr Policy and Res. 1(7):197–204
5. Ayranci, E. and S. Tunc .2004. The effect of edible coatings on water and vitamin c loss of apricots (Armeniaca vulgaris lam.) and green peppers (Capsicum annum l.). Food Chemistry, 87(3): 339-342
6. Ayranci, E. and S. Tunc .2003. A method for the measurement of the oxygen permeability and the development of edible films to reduce the rate of sulfur oxidative reactions in fresh foods. Agricultural Science Journal. 80(3): 423-431
7. Alhassan, N., M. C. Bowyer, R. B. H. Wills, J. B. Golding and P. Pristijono .2020. Postharvest dipping with 3,5,6-trichloro-2-pyridiloxycetic acid solutions delays calyx senescence and loss of other postharvest quality factors of ‘Afoourer’ mandarins, Navel, and Valencia oranges. Scientia Horticulturae, vol. 272:109572.
https://doi.org/10.1016/j.scienta.2020.109572
8. Brummell, D. A. and M. H. Harpster .2001. Cell wall metabolism in fruit softening and quality and its manipulation in transgenic plants. Plant Molecular Biology, 47: 311 – 339
9. Duncan, D. B, .1955. Multiple Range and Multiple F. Tests. Biometrics, 11: 1-42
10. El-Badawy, H. Z. M .2007. Trials to Improve Marketing Characteristics and Prolonging Storage Life of Persimmon and Mango Fruits. Ph.D. Dissertation, Benha Uni., Egypt. pp:342
11. El-Gioushy, S. F. .2012. Physiological and Anatomical Studies on some Factors Affecting Productivity and Nutritional Status of Navel Orange. Ph.D. Dissertation. Faculty of Agriculture Benha University. Egypt. 177
12. Eman, A.A.; H.M. Kamel; Z.A. Zaki and M.E. Abo Rehab .2015. Effect of honey and citric acid treatments on postharvest quality of fruits and fresh-cut of guava. World Journal of Agricultural Sciences 11 (5): 255- 267
13. Grierson, W. and W. M. Miller. 2006. Storage of citrus fruit. In Fresh citrus fruits, 2nd ed. Wardowski; Florida Science Source. Inc., Florida, USA.
14. Hussein, A. M., M. B. El-Sabrou and A. E. Zaghoul .1998. Postharvest physical and biochemical changes of common and late types of seedy guava fruits during storage. Alex. J. Agric. Res. 43(3): 187-204
15. Jasim, A. F .2014. Studies on Storage of Valencia Orange Fruits. M.Sc. Thesis. Fac. Agric. Cairo Univ, Egypt
16. Jiang, T., L. Feng and X. Zheng .2012. Effect of chitosan coating enriched with thyme oil on postharvest quality and shelf life of shiitake mushroom (Lentinus edodes). Journal of Agricultural Food Chemistry, 60(1): 188-196
17. Joe, M. M., J. Jayachitra, and M. Vijayapriya .2009. Antimicrobial activity of some common spices against certain human pathogens. J. Med. Plant 3(11)
18. Karomi, M. F. .2001. Effect of Some Growth Regulators on Sexual Ratio and Yield Characteristics of Two Pomegranate Cultivars El- Saleemi and Rawa Seedlees. M.Sc. Thesis, Hort. Dept., Agric. Coll., Mosul Uni., Iraq. (In Arabic)
19. Kumar, M and J. S. Berval .1998. Sensitivity of food pathogens to garlic (Allium Sativum). J. Appl. Microbiol., 84(2): 213-215
20. Lee, L., J. Arul, R. Lencki, and F. Castaigne .1995., A review on modified atmosphere packaging and preservation of fresh fruits and vegetables: Physiological basis and practical aspects Part I. Packaging, Technology and Science, 8(6): 315-331
21. Martinez, M. V. and J. R. Whitaker .1995. The biochemistry and control of enzymatic browning. Trends of Food Science and Technology, 6: 195-200
22. Michael, D. .2000. Common spices protect bacteria during irradiation. Am. Chem Sci. 2: 270–275.
23. Mittler, R. .2002. Oxidative stress, antioxidants, and stress tolerance. Trends Plant Sci. 7(9): 405–410
24. Patrignani, F., Siroli, L., Serrazanetti, D. I.; Gardini, F. and R. Lanciotti
2015. Innovative strategies based on the use of essential oils and their components to improve safety, shelf-life, and quality of minimally processed fruits and vegetables. Trends in Food Science and Technology, 46(2): 311-319
25. Plesoianu, A. M., F. Tutulescu, and V. Nour. 2020. Postharvest antimicrobial treatments with organic acids to improve the shelf life of fresh blueberries. Notulæ Botanicae Horti Agrobotanici Cluj-Napoca, 48(1): 90-101.
26. Ribeiro, R. V. and E. C. Machado. 2007. Some aspects of citrus ecophysiology in subtropical climates: re-visiting photosynthesis under natural conditions. Brazilian Journal of Plant Physiology 19, 393–411
27. Salvatava D. K. 2010. Pomology Fruit Sciences. Rivistadella, Ortoflorofrutticollura. Italia
28. Samad M., M. Sajid, I. Hussain, N. Samad and N. Jan. 2019. Influence of herbal extract and storage duration on fruit quality of china lime. Horticult Int J. ;3(3): 153-158.
29. Samita, T., S. Saroj, and A. Debraj. 2020. Effect of different postharvest treatments on prolonging shelf life and maintaining quality of sweet orange (Citrus sinensis Osbeck.), sustainability in food and Agriculture (SFNA), Zibeline International Publishing, 1(2): 69-75
30. Shirin, S. and R. Asghar. 2014. Effect of natural Aloe vera gel coating combined with calcium chloride and citric acid treatments on grape (Vitis vinifera L. Cv. Askari) quality during storage. American Journal of Food Science and Technology, 2(1): 1-5
31. Sowani, A. and Z. Zahng. 2011. Postharvest characterization of cherry tomato stored in cold storage under ambient conditions. Horticultura Braileira., 18(1): 46-48
32. Sommers, C. H.; X. T. Fan; A. P. Handel and K. B. Sokorai. 2003. Effect of citric acid on the radiation resistance of Listeria monocytogenes and frankfurter quality factors. Meat Science, 63(3): 407-415.
33. Yang, C., C. Tao, S. Borui, S. Shuxia, S. Haiyan, C. Dong and X. Wanpeng. 2019. Citric acid treatment reduces decay and maintains the postharvest quality of peach (Prunus persica) fruits. Food Science and Nutrition, 7(11): 3635–3643
34. Zeng, K., Y. Deng, J. Ming and L. Deng. 2010. Induction of disease resistance and ROS metabolism in navel oranges by chitosan. Sci. Hortic., 126, 223–228
35. Zhang J., Li Zeng, H. Sun, J. Zhang and S. Chen. 2017. Using chitosan combined treatment with citric acid as edible coatings to delay postharvest ripening process and maintain tomato (Solanum lycopersicon Mill) quality. J. Food and Nutrition Research. 5(3): 144-150.