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.

مجلة العلوم الزراعية العراقية -2022 :53(4):850-856 **الهاجاني وأخرون**

تاثير حامض الستريك ومستخلص الزنجبيل ومدة التخزين على جودة ثمار البرتقال(*Citrus sinensis* L. Osbeck) المحلي

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المستخلص

اجريت الدراسة على ثمار البرتقال المحلي(*Citrus sinensis* L. Osbeck) المزروعة في احدى البساتين الاهلية التابعة لمحافظة ديالى/ العراق والمختبر المركزي في كلية علوم الهندسة الزراعية/ جامعة دهوك ، لدراسة تأثير الغمر لمدة 10 دقائق في (0 و 1 و2 و3% حامض الستريك و 5 و 10% مستخلص الزنجبيل) في الصفات الخزنية لثمار البرتقال خلال التخزين البارد لمدة 65 و105 يوم على درجة 5+1م ورطوبة نسبية 85-90%. غمر الثمار في مستخلص الزنجبيل 5 و 10 % اثر معنويا في نسبة الحموضة ونسبة السكريات الكلية ونسبة السكريات لى الحموضة ، في حين قللت من نسبة الفقدان بالوزن والثمار التالفة. ادى غمر الثمار في محلول حامض الستريك الى التقليل من نسبة فقدان الوزن و نسبة الثمار التالفة. عند غمر الثمار في مستخلص الزنجبيل 5% ادى الى انخفاض معنوي في محتوى القشرة من الكاروتين وزيادة معنوية من كمية فيتامين(C). اطالة مدة التخزين من 65-105 يوم زادت وبصورة معنوية من نسبة المواد الصلبة الذائبة الكلية للثمار ونسبة الفقدان بالوزن ونسبة السكريات الكلية ومحتوى القشرة من الكاروتين, ومن جهة اخرى قللت من كمية فيتامين (C) والحموضة الكلية. كان للتداخل بين معاملات الغمر ومدة الخزن تاثيرا معنويا على جودة ونوعية ثمار البرتقال.

كلمات مفتاحية: البرتقال، حامض عضوي، مستخلص نباتي، بعد الحصاد

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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, paradole, 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 orang fruits 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℃ 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 know 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-Elghany *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).

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

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
	65	105	effect
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 ef	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 the (Table 4) confirm that, the wight loss present decreased in all treatments compared with control. Fruit juice percentage was not influenced by the storage period (65 to105) days. The highest fruit juice percentage resulted from the interaction between 10% ginger and 105 days storage period as compared with the lowest fruit juice percentage that resulted from 2% citric acid and 105 days storage period.

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
	65	105	effect
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 weight 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 orang stored at 5+1 ˚C

Treatments	Storage period(day)		Treatments
	65	105	effect
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 a l* (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 increases in fruit decay depending on the progress of the storage period of the fruits but not reached a significant increases. 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, pectatelyase, 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 orang stored at 5+1 ˚C

Treatments	Storage period (day)		Treatments
	65	105	effect
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.

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