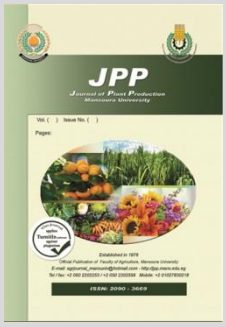
**Journal of Plant Production**

**Journal homepage: www.jpp.mans.edu.eg**
**Available online at: www.jpp.journals.ekb.eg**

# Effect of Some Antioxidant Agents on Quality Attributes and Storability of Fresh Cut Taro

**Mona M. Haffez[1*] ; Samia S. A. Elkeleny[2] and Amani H. A. M. Gharib[3]**

[1]Department of Postharvest and Handling of Vegetable Crops, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.
[2]Department of Postharvest and Handling of Vegetable Crops, Horticulture Research Institute, Agricultural Research Center, Sbaheya, Alex. Egypt.
[3]Department of Vegetable , Medicinal & Aromatic Plants Breeding , Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.




## ABSTRACT

This study was carried out on Taro (*Colocasia esculenta* L.) which were harvested in the suitable maturity stage of marketing on 8th and 5th of January in the 2019 and 2020 seasons, respectively, from El-Qanater Vegetable Research Farm, Qalyubia Governorate then delivered to the laboratory of Vegetable Handling Department, Horticulture Research Institute, Agriculture Research Centre, Egypt, during two successful winter seasons to study the effects of some postharvest treatments such as cysteine at 1%, citric acid at 1%, ascorbic acid at1%, salicylic acid at 1% in combination with calcium lactate at 1% for 5 min and calcium lactate alone at 1% for 5 min compared with distilled water for 5 min as a control treatment on maintaining quality and storability of fresh- cut taro during storage at 4° C and 95% relative humidity (RH.) for 12 days. Results revealed that all postharvest treatments significantly maintained the quality attributes of fresh cut taro compared with untreated control during cold storage. Fresh cut taro dipped in salicylic acid at 1% in combination with calcium lactate at 1% for 5 min and calcium lactate alone at 1% for 5 min were the most effective treatments for reducing loss of both weight and texture, maintaining general appearance and inhibition of discoloration in the cut surface. Moreover, these treatments had lower level of microbial load and reducing polyphenol oxidase (PPO) activity as compared with other treatments.

***Keywords:*** Fresh cut, Taro, Antioxidant agents, Quality attributes, Storability

## INTRODUCTION

The rising popularity of minimally-processed fruit has been credited to consumer's demand for the convenience of fresh-cut products and the health features associated with fresh produce. Fruits and vegetables are showing a quick change in quality due to aging, biochemical changes, rise in respiration rate and the proliferation of microorganisms that occur during processing and distribution (Martin-Belloso *et al*., 2007).

Taro is a typical root vegetable tuber tropical and subtropical crop belongs to Araceae family, it is similar lotus roots and burdocks (Lee *et al*., 2007). Taro is a starch-rich corm, taro has 70-80/100 g starch and is rich in gums (mucilage) (up to 9.1%). Taro also contains 0.6-0.8/100 g fiber, 2-6/10a protein, vitamins, phosphorus and calcium, zinc, copper and manganese. Although, fresh cut fruit are easier and consumers preferred it but the respiration rates increase, biochemical reactions, microbiological spoilage and quality decay.

Peeling and cutting taro corms accelerates respiration rate more than in intact taro corms. Therefore, the quality of fresh cut taro decreased rapidly due to exposure of inner fresh to environment, thus they have much shorter shelf life 3 days at 4°C (Chang and Kim 2015). In particular, browning of surfaces exposure by peeling and chopped can be a problem (Aly *et al*., 2017). In order to prevent the loss of quality and the browning of fresh cut taro, it is necessary to use some antioxidant agents, such as cysteine (Garcia-Molina *et al*., 2005), citric acid (Javan *et al*., 2015), ascorbic acid (Jang *et al*., 2011), salicylic acid, (Asgharia and Aghdam, 2010) and calcium lactate (Gad El-Rab 2019) as postharvest treatment in conjunction with low temperature to extend shelf life of fresh cut taro.

Cysteine is investigated as an anti-browning agent and an effective inhibitor of enzymatic browning. also, its activity was attributed to various mechanisms such as its nucleophile reactivity towards quinones to give colorless adduct (Garcia-Molina *et al*., 2005), its inhibitory effect towards poly phenol oxidase and / or its ability to reduce o-quinones to their poly phenol precursors (Altunkaya and Gökmen, 2008).

Citric acid has inhibitory effect on poly phenol oxidaze (PPO) as a potential anti-browning agent in slightly processed vegetable. It is widely used as a food active and an antimicrobial factor by virtue of their low pH in food industry dipping in Citric acid before storage can preserve bioactive component and antioxidant characteristics of fresh cut food during storage. Citric acid is able to tardiness PPO enzyme action by decrease the pH of fruit tissue and co-enzyme. Significantly, higher retention of phenolic compounds is due to of the anti- browning and anti-senescence properties of citric acid (Javan *et al*., 2015).

Ascorbic acid is effective in lowering browning. It is generally renowned as secure, cheap and consumer friendly.

* **Corresponding author.**
**E-mail address: mona.montasser75@gmail.com**
**DOI: 10.21608/jpp.2020.149825**

Ascorbic acid able to minimize O-quinones, produced by PPO-catalyzed oxidation of poly phenols, back to dihydroxy poly phenols and has been widely applied as an anti-browning agent for processing of fruits and vegetables. However, the effect of ascorbic acid is passing, it is completely oxidized once it is added and O-quinones could accumulate, leading to browning pigment forming. Ascorbic acid could be effective in decrease the respiration rate and ethylene production in fresh cut fruit (Jang *et al*., 2011).

Salicylic acid, as a safe and natural phenolic compound, exhibits a high possibility for controlling post-harvest losses of vegetable and fruit crops (Asgharia and Aghdam, 2010). According to the reports of Cao *et al*. (2013), salicylic acid inhibited disease in fruit infected with *Alternaria alternata*. Salicylic acid increases defense enzymes of Phenylalanine ammonia lyase (PAL), Peroxidase (POD) and glucanase (GLU) activities in fruit during storage. Also, salicylic acid treatment declined Choline catalase (CAT) activity and increased Superoxide dismutase (SOD) activity and ascorbate (AA) content in fruit. Salicylic acid increases hydrogen peroxide ($H_2O_2$) accumulation in fruit via binding to CAT, and accumulation of $H_2O_2$ contributes to signal transduction pathway leading to systemic acquired resistance (SAR) activation. Also, salicylic acid could increase $H_2O_2$ accumulation via increasing SOD activity, which is responsible for formation of $H_2O_2$ from $O_2$ generated during infection.

Calcium lactate has the advantage that it avoids the bitterness or off- flavors associated with other salts. Calcium lactate has been reported to have potent anti-bacterial properties owing to its ability to uncouple microbial transport processes (Luna-Guzman and Barrett, 2000).

Therefore, this study was conducted to examine the effect of some antioxidant agents on quality attributes and storability of fresh cut taro during cold storage.

## MATERIALS AND METHODS

Taro corms (*Colocasia esculenta* L. Schott Balady cultivar) were harvested in the suitable maturity stage of marketing (full ripening) on 8$^{th}$ and 5$^{th}$ of January in the 2019 and 2020 seasons, respectively, from El- Qanater Vegetable Research Farm, Qalyubia Governorate then delivered to the laboratory of Vegetable Handling Department, Horticulture Research Institute, Agriculture Research Centre, Giza Governorate, Egypt. The corms were kept to curing at 20° C and 85% relative humidity (RH). for five days, corms were selected with uniformity of size ( 750-1000g/ corm) and free of visual damage or defects. Taro corms were washed initially with water and then air dried. All sharp knives, cutting boards and other equipment which come into contact with the corms were sanitized by immersion in 1000mg/L sodium hypo chloride solution for 30min before cutting. The skin corms were removed and corms were cut longitudinally into two halves then each half cut into pieces that approximately 2-2.2 cm thickness, the samples of fresh cut taro were randomly divided into 6 groups and then treated with the following treatments:

1. Dipping in solution of cysteine at 1% and calcium lactate at 1% for 5 min.
2. Dipping in solution of citric acid at 1% and calcium lactate at 1% for 5 min.
3. Dipping in solution of ascorbic acid at1% and calcium lactate at 1% for 5 min.
4. Dipping in solution of salicylic acid 1% and calcium lactate at 1% for 5 min.
5. Dipping in solution of calcium lactate alone at 1% for 5 min.
6. Dipping in distilled water for 5 min as an untreated control.

All treatments of fresh cut taro were air dried, placed on polystyrene trays and then wrapped with sealed poly-propylene 30 Mm thicknesses film and each had 250g of fresh cut taro represented as one replicate. Fifteen replicates for each treatment were prepared and stored at 4ºC and 95% relative humidity for 12 days. Measurements were examined immediately after treatment and every 3 days interval for the following parameters:

**1- Weight loss (%):** It was calculated according to the equation:

$$\text{Weight loss \%} = \frac{\text{Initial weight of pieces- Weight of pieces at sampling date}}{\text{Initial weight of pieces}} \times 100$$

**2- General appearance:** was evaluated using a scale from (9-1) were 9= excellent, 7= good, 5=fair, 3= poor and 1=unsalable. Samples rating (5) or below were considered as non-marketable.

**3- Discoloration:** Discoloration was evaluated as a scale of 1 to 5 where 1= none, 2= slight, 3= moderate, 4= severe and 5= extra severe as described by Cantwell *et al*. (2009).

**4- Decay score:** Decay was measured on a scale of 1= none, 2= slight, 3= moderate, 4= severe and 5= extreme (Risse and Miller, 1986**).**

**5- Color:** Color was measured on two sides of each piece by using Tistimulus Hunter colorimeter Minolta, Ramsey, N.J. (Model Dp 9000 which measured L*, b* and a* value) (McGuire, 1992).

**6- Texture:** Texture of fresh cut taro was recorded by TA-1000 texture analyzer instrument using a penetrating cylinder of 1 mm diameter, to a constant distance (3 and 5 mm) inside the pulp of pieces, and by a constant speed 2 mm per sec., and the peak of resistance was recorded in g/cm$^2$.

**7- Polyphenol Oxidase Activity (PPO):** Polyphenol Oxidase activity (PPO, E.C. 1.14.18.1) in taro pieces extract during the storage period was determined according to Pizzocaro *et al*. (1993).

**8- Total microbial count (TMC):** The population of total microbial count (TMC) was determined by the method of Marshall (1992).

**Statistical Analysis :**

The experiment was factorial with 2 factors (cold storage period and antioxidant treatments) in complete randomized design (CRD) with 3 replicates according to the methods described by Sendecor and Cochran (1980). Comparison between means was evaluated by Tukey's multiple range test.at 5% level of significance.

## RESULTS AND DISCUSSION

**Weight Loss Percentage**

Data in Table 1 indicated that there were significant increases in weight loss with extending cold storage period in the two tested seasons. Similar results were obtained by

Aly *et al*. (2017) on fresh cut taro. Results can be attributed to the loss of water which is relatively easy to evaporate, respiration and other senescence related metabolic processes during storage. These were in agreement with those obtained by Vasey (2006).

Concerning the effect of antioxidant treatments, data revealed that all treatments retained their weight during storage as compared with control. Moreover, fresh cut taro treated with salicylic acid plus calcium lactate was the most effective treatment for reducing the weight loss percentage during cold storage in the two tested seasons. Meanwhile, the highest value of weight loss percentage was recorded with the untreated control. These results were in agreement with Attia (2014) for calcium lactate; Gad El-Rab (2019) for citric acid or salicylic acid; Saleh *et al*. (2013) for cysteine or ascorbic acid or citric acid and Kasim *et al*. (2015) for ascorbic acid. This may be due to that these agents might reduce respiration rate of the product and inhibited the physiological processes, which in turn reduced weight loss % during storage, these were in agreement with those obtained by (Luna-Guzman and Barrett 2000). Weight loss is mainly regulated by respiration, transpiration and metabolic activities in fruits. Salicylic acid has been reported to close stomata which results in suppressed respiration rate and minimized weight loss of fruits (Zheng and Zhang, 2004).

Concerning the interaction between antioxidant and storage periods, data indicated that fresh cut taro treated with salicylic acid plus calcium lactate was the most obvious treatment in reducing the loss of weight percentage during all storage periods. However, the highest weight loss value was recorded by the untreated control in both seasons.

**Table 1. Effect of some antioxidant agents on weight loss (%) of fresh cut taro during cold storage at 4° C in 2019 and 2020 seasons.**

| Treatments | Storage period (days) | | | | |
|---|---|---|---|---|---|
| | 2019 | | | | |
| | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.13 ef | 0.21 ef | 1.32 b-d | 2.00 ab | 0.91 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.11 ef | 0.15 ef | 1.29 cd | 1.85 a-c | 0.85 BC |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.08 f | 0.13 ef | 1.12 d | 1.27 cd | 0.65 BC |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 0.03 f | 0.10 f | 0.44 ef | 0.78 de | 0.34 D |
| Calcium lactate 1% for 5 min | 0.25 ef | 0.32 ef | 0.67 d-f | 1.28 cd | 0.63C |
| Control | 0.28 ef | 0.34 ef | 1.80 a-c | 2.46 a | 1.22 A |
| Mean | 0.15 C | 0.21 C | 1.11 B | 1.60 A | |
| Treatments | 2020 | | | | |
| | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.55 e-g | 0.83 c-g | 1.50 b-e | 2.00 ab | 1.21 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.50 e-g | 0.76 c-g | 1.31 b-f | 1.94 ab | 1.13 B |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.37 fg | 0.68 d-g | 1.24 b-f | 1.78 a-c | 1.02 B |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 0.04 g | 0.15 g | 0.46 c-g | 0.97 b-g | 0.41 C |
| Calcium lactate 1% for 5 min | 0.32 fg | 0.56 e-g | 1.02 b-g | 1.66 a-d | 0.89 B |
| Control | 1.33 b-f | 1.66 a-d | 2.00 ab | 2.70 a | 1.92 A |
| Mean | 0.52 C | 0.78 C | 1.25 B | 1.87 A | |

**Values with the same letter(s) are not significantly different at P≤ 0.05 level; using Tukey's multiple range test.**

**General Appearance (GA)**

Data in Table 2 show that general appearance (score) of fresh cut taro was decreased with the prolongation of storage period. The decreases in general appearance during storage might be due to shriveling, color change and decay. Similar results were reported by (Chang and Kim, 2015) on fresh cut taro.

**Table 2. Effect of some antioxidant agents on general appearance (score) of fresh cut taro during cold storage at 4° C in 2019 and 2020 seasons.**

| Treatments | Storage period (days) | | | | | |
|---|---|---|---|---|---|---|
| | 2019 | | | | | |
| | **0** | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 9.00 a | 9.00 a | 7.67 a-c | 7.00 a-d | 6.33 b-e | 7.80 A |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 9.00 a | 9.00 a | 6.33 b-e | 4.33 e-g | 2.33 gh | 6.20 B |
| Ascorbic acid 1%+Calcium lactate 1% for 5 min | 9.00 a | 9.00 a | 7.67 a-c | 5.67 c-e | 2.33 gh | 6.73 B |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 9.00 a | 9.00 a | 8.33 ab | 7.67 a-c | 7.00 a-d | 8.20 A |
| Calcium lactate1%for5 min | 9.00 a | 9.00 a | 7.67 a-c | 7.00 a-d | 5.00 d-f | 7.53 A |
| Control | 9.00 a | 7.67a-c | 5.00 d-f | 3.00 f-h | 1.67 h | 5.27 C |
| Mean | 9.00 A | 8.78 A | 7.11 B | 5.78 C | 4.11 D | |
| Treatments | 2020 | | | | | |
| | 0 | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 9.00 a | 9.00 a | 9.00 a | 6.33 b-e | 5.00 d-f | 7.67 AB |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 9.00 a | 9.00 a | 6.33 b-e | 5.00 d-f | 4.33 ef | 6.73 C |
| Ascorbic acid 1%+Calcium lactate 1% for 5 min | 9.00 a | 9.00 a | 7.00 a-d | 5.67 c-f | 4.33 ef | 7.00 BC |
| Salicylic acid 1%+Calcium lactate 1% for 5 min | 9.00 a | 9.00 a | 9.00 a | 7.67 a-c | 7.00 a-d | 8.33 A |
| Calcium lactate1%for5 min | 9.00 a | 9.00 a | 8.33 ab | 7.67 a-c | 6.33 b-e | 8.07 A |
| Control | 9.00 a | 8.33 ab | 5.67 c-f | 3.67 fg | 1.67 g | 5.67 D |
| Mean | 9.00 A | 8.89 A | 7.56 B | 6.00 C | 4.78 D | |

**Values with the same letter(s) are not significantly different at P≤ 0.05 level; using Tukey's multiple range test.**

It was noticed that all treatments were better than the untreated control, however, fresh cut taro dipped in solution of salicylic acid, cysteine together with calcium lactate and calcium lactate alone were the most effective treatments for maintaining general appearance during storage with insignificant differences between each other, in both seasons and these treatments gave the highest score of appearance. Fresh cut taro treated with citric acid or ascorbic acid +

calcium lactate were less effective treatments in maintaining general appearance. Meanwhile the untreated (control) recorded the lowest score in this concern.These results were true in, the two seasons and agree with those reported by Gad El-Rab (2019) for citric acid or salicylic acid or calcium lactate; Saleh *et al.* (2013) for cysteine and Kasim *et al.* (2015) for ascorbic acid. Maintaining of visual quality by using cysteine or salicylic acid together with calcium lactate or calcium lactate alone may be due to the effect of these treatments on the reduction of respiratory activity, degradation by enzymes, microbial rot of fruit and gave lower color change. This may be due to that calcium lactate reduced incidence of physiological disorders, decay and delayed senescence of fresh cut (Lamikanra and Watson, 2007). Meanwhile, salicylic acid in combination with calcium lactate rated good appearance after 12 days in the two tested seasons.

Concerning the interaction between antioxidant treatments and storage periods on general appearance, data recorded that fresh cut taro dipped in salicylic acid in combination with calcium lactate gave the best appearance; as it did not exhibit any changes in their appearance till 6$^{th}$ days at 4°C and gave good appearance at the end of storage period (12 days) in both seasons. Meanwhile, cysteine in combination with calcium lactate rated good appearance after 9 days of storage in the first season only. However, calcium lactate gave good appearance after 9 days of storage, in the both season. On the other hand, the untreated control had the poorest appearance in the same period of storage.

**Discoloration**

Data in Table 3 indicated that there were increments in discoloration for the cut surface of taro as the storage period prolonged. The change in color development is primarily related to the oxidation of phenolic compounds to o-quinines a reaction, catalyzed by poly phenol oxidase (PPO). Quinines then polymerize to dark brown, black or red polymers. These results were true in both seasons and were in an agreement with those reported by Chang and Kim (2015) on fresh cut taro.

**Table 3. Effect of some antioxidant agents on discoloration (score) of fresh cut taro during cold storage at 4° C in 2019 and 2020 seasons.**

| Treatments | Storage period (days) | | | | | |
|---|---|---|---|---|---|---|
| | 2019 | | | | | |
| | **0** | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 1.00 h | 1.00 h | 2.00 e-h | 2.33 d-g | 4.67 ab | 2.20 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 1.00 h | 1.00 h | 1.67 f-h | 2.67 c-f | 3.33 cd | 1.93 B |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 1.00 h | 1.00 h | 2.00 e-h | 3.00 c-e | 3.67 bc | 2.13 B |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 1.00 h | 1.00 h | 1.00 h | 1.00 h | 1.33 gh | 1.07 C |
| Calcium lactate 1% for 5 min | 1.00 h | 1.00 h | 1.00 h | 1.67 f-h | 2.00 e-h | 1.33 C |
| Control | 1.00 h | 2.00 e-h | 3.33 cd | 4.67 ab | 5.00 a | 3.20 A |
| Mean | 1.00 D | 1.17 D | 1.83 C | 2.56 B | 3.33 A | |
| Treatments | 2020 | | | | | |
| | 0 | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 1.00 f | 1.00 f | 2.00 d-f | 2.33 ce | 4.33 ab | 2.13 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 1.00 f | 1.00 f | 1.33 ef | 2.67 cd | 3.33 bc | 1.87 B |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 1.00 f | 1.00 f | 1.67 d-f | 3.33 bc | 4.33 ab | 2.27 B |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 1.00 f | 1.00 f | 1.00 f | 1.00 f | 1.33 ef | 1.07 C |
| Calcium lactate 1% for 5 min | 1.00 f | 1.00 f | 1.00 f | 1.33 ef | 2.00 d-f | 1.27 C |
| Control | 1.00 f | 1.67 d-f | 3.33 bc | 4.33 ab | 5.00 a | 3.07 A |
| Mean | 1.00 D | 1.11 D | 1.72 C | 2.50 B | 3.39 A | |

**Values with the same letter(s) are not significantly different at P≤ 0.05 level; using Tukey's multiple range test.**

Regarding the effect of some antioxidant agents, data revealed that all the used treatments, significantly, reduced the incidence of discoloration compared to the untreated control. However, fresh cut taro dipped in salicylic acid plus calcium lactate or calcium lactate alone were the most effective treatments in preventing the discoloration in the cut surface of species which gave the lower score of discoloration with insignificant differences between each other, followed by other treatments with insignificant differences among them. On the contrary, the untreated control recorded the highest discoloration score during cold storage. These results were true in the two seasons and were in an agreement with Gad El-Rab (2019) for calcium lactate or salicylic acid; Saleh *et al.* (2013) for cysteine or citric acid and Kasim *et al.* (2015) for ascorbic acid.

The reduction in discoloration in the cut surface of fresh cut taro by using calcium lactate may be due to reducing polyphenol oxidase activity and preserving the total phenolic content and reducing the color change of the cut surface (Gad El-Rab, 2019). Citric acid has been reported extensively for its inhibitory effect on PPO, so it is recommended as a potential anti-browning agent in minimally processed fruits and vegetables. It lowers the pH and chelates the copper at the active site of the PPO. Its inhibitory effect could be related to the phenolase Cu-chelating power. Especially at pH values below 4, the looser binding of copper at the active enzyme site causes the PPO activity to decrease further, permitting the citric acid to remove the copper, these were in agreement with those obtained by Ibrahim *et al.* (2004). Successful browning inhibiting by reducing agents, ascorbic acid is attributed to the reduction of quinones back to diphenols or the reduction of $Cu^{2+}$ to mononuclear copper($Cu^{+}$) at the PPO active site (Suttirak and Manurakchinakoran, 2010).

Regarding the interaction between antioxidant agent's treatments and storage periods on the discoloration, data revealed that fresh cut taro treated with salicylic acid in combination with calcium lactate did not show any changes in their color till the end of storage (12 days). However, calcium lactate treatment gave slight score. Meanwhile, ascorbic acid or cysteine in plus calcium lactate gave severe score after the same period in both seasons. It was noticed that the untreated control resulted in extra severe

discoloration with the highest score, in the two tested seasons.

**Decay Percentage**

Data in Table 4 indicated that there were increases in decay percentage with the prolongation of storage period, these results were true in the two seasons and were in an agreement with those reported by Luna-Guzman and Barrett (2000) and Attia (2014).

Concerning the effect of antioxidant treatments, data revealed that all postharvest treatments were much better in reducing decay and thus longer storage periods were gained compared to the untreated control. Fresh cut taro dipped in citric acid, ascorbic acid or salicylic acid in combination with calcium lactate or calcium lactate alone were the most effective treatment in minimized decay incidence during storage with insignificant difference between each other in the two seasons. These results were true, in the second season. However, untreated control obtained the highest decay incidence during storage. These results were in an agreement with those reported by Cao *et al.* (2013) for salicylic acid; Rico *et al*. (2007) for citric acid.

Citric acid has been described as strong antimicrobial agents against psychrophilic and mesophilic microorganisms in fresh-cut fruits and vegetables. citric acid and ascorbic acid were used to reduce microbial populations on salad vegetables (Rico *et al*., 2007).

Concerning the interaction among antioxidant treatments and storage periods, results revealed that, for the untreated control, the decay fruits started to be shown after 6 days of storage, in the two seasons. However, no decay was observed in fruits treated with citric acid, ascorbic acid or salicylic acid in combination with calcium lactate during all storage periods, in the first season.

**Table 4. Effect of some antioxidant agents on decay percentage of fresh cut taro during cold storage at 4° C in 2019 and 2020 seasons.**

| Treatments | Storage period (days) | | | | | |
|---|---|---|---|---|---|---|
| | 2019 | | | | | |
| | **0** | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.00 d | 0.00 d | 0.00 d | 0.00 d | 5.47 bc | 1.09 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.00 d | 0.00 d | 0.00 d | 0.00 d | 0.00 d | 0.00 C |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.00 d | 0.00 d | 0.00 d | 0.00 d | 0.00 d | 0.00 C |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 0.00 d | 0.00 d | 0.00 d | 0.00 d | 0.00 d | 0.00 C |
| Calcium lactate1% for5 min | 0.00 d | 0.00 d | 0.00 d | 0.00 d | 1.22 d | 0.25 BC |
| Control | 0.00 d | 0.00 d | 4.20 c | 7.93 b | 11.28 a | 4.68 A |
| Mean | 0.00 C | 0.00 C | 0.70 BC | 1.32 B | 3.00 A | |
| Treatments | 2020 | | | | | |
| | 0 | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.00 e | 0.00 e | 0.00 e | 0.00 e | 7.20 bc | 1.44 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.00 e | 0.00 e | 0.00 e | 0.00 e | 3.33 c-e | 0.67 BC |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.00 e | 0.00 e | 0.00 e | 0.00 e | 2.88 de | 0.58 BC |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 0.00 e | 0.00 e | 0.00 e | 0.00 e | 0.00 e | 0.00 C |
| Calcium lactate1% for5 min | 0.00 e | 0.00 e | 0.00 e | 0.00 e | 4.17 cd | 0.83 BC |
| Control | 0.00 e | 0.00 e | 6.50 b-d | 9,00 b | 14.64 a | 6.02 A |
| Mean | 0.00 C | 0.00 C | 1.08 BC | 1.50 B | 5.37 A | |

**Values with the same letter(s) are not significantly different at P≤ 0.05 level; using Tukey's multiple range test.**

**Color**

Data in Tables 5 and 6 show the effect of antioxidant treatments on color of fresh cut taro during cold storage. The color of fresh cut taro was analyzed recording L and a values. The L value, a general representation of surface reflectivity is used to express the luminosity of the sample surface. a value indicate chromaticity on green (-) to red (+) axis. Color is a critical quality attribute of fresh-cut fruits and vegetables since cutting often leads to enzymatic browning. Color changes due to wound-induced response caused by peeling and slicing are also expected, these were in agreement with those obtained by Siomos *et al.* (2010). Table 5 show that there was decrease in L value for all treatments and untreated control continuously with extending the storage period, indicating that the browning process of cut surface developed and reached darker with storage, darkening of fruits and vegetables associated with decreased L values may be linked to dehydration. These results were true in the two seasons and were in an agreement with Chang and Kim (2015) on fresh cut taro.

Concerning the effect of antioxidant agents treatments, the best results were observed for fresh cut taro dipped in salicylic acid in combination with calcium lactate, followed by calcium lactate alone that gave the highest L value (indicated lighter color) with no significant different between them in the second season. Meanwhile fresh cut taro treated with distilled water (control) had darker color (low L value). The initial bright color had largely disappeared after the same period. These results were true in the two seasons and were in an agreement with those reported by Mohamed *et al*. (2015) for cysteine and ascorbic acid.

Concerning the interaction among antioxidant agents treatments and storage periods, results revealed that the highest L value was observed for fresh cut taro dipped in salicylic acid in combination with calcium lactate after 12 days of storage (end of storage period), in the two season, while lowest value of L was observed in samples treated with untreated control at the same period of storage, in the two season.

Data in Table 6 show that a value of fresh cut taro increased with the prolongation of storage period and this value increased most rapidly for the untreated taro compared to the other samples (indicated color change and browning). These results are in an agreement with Aly *et al*., (2017) on fresh cut taro and may be due to Polyphenol oxidase (PPO) which is a key enzyme responsible for browning in fruits and vegetables by catalyzing the oxidation of phenolic

compounds, resulting in the formation of melanins (Budu and Joyce, 2003). Our data indicate that treatment with calcium lactate and salicylic acid in combination with calcium lactate contributed to a slower accumulation of red pigmentation on taro surface and delayed browning in two seasons.

**Table 5. Effect of some antioxidant agents on L* value of fresh cut taro during cold storage at 4° C in 2019 and 2020 seasons.**

| Treatments | Storage period (days) | | | | | |
|---|---|---|---|---|---|---|
| | 2019 | | | | | |
| | **0** | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 87.32 a | 84.33 a-f | 82.42 a-h | 81.87 a-i | 77.95 e-i | 82.78 B |
| Citric acid 1%+Calcium lactate 1% for 5 min | 87.32 a | 83.01 a-g | 79.23 c-i | 79.22 c-i | 78.63 d-i | 80.79 B |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 87.32 a | 83.78 a-g | 82.06 a-i | 80.36 b-i | 78.21 d-i | 82.35 B |
| Salicylic acid 1%+Calcium lactate 1% for 5 min | 87.32 a | 85.95 ab | 85.55 a-c | 84.81 a-d | 84.50 a-e | 85.63 A |
| Calcium lactate 1% for 5 min | 87.32 a | 84.74 a-d | 83.34 a-g | 81.32 a-i | 77.30 g-i | 82.80 B |
| Control | 87.32 a | 79.48 b-i | 78.00 f-i | 75.57 i | 68.62 j | 77.74 C |
| Mean | 87.32 A | 83.55 B | 81.72 BC | 79.95 C | 77.53 D | |
| Treatments | 2020 | | | | | |
| | 0 | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 72.87 a | 71.92 a | 71.11 ab | 68.87 a-d | 68.09 a-e | 70.57 A |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 72.87 a | 70.34 a-c | 69.46 a-d | 68.93 a-d | 68.39 a-e | 70.00 A |
| Ascorbic acid1%+Calcium lactate1% for 5 min | 72.87 a | 70.39 a-c | 66.20 a-e | 62.07 d-f | 60.50 ef | 66.43 B |
| Salicylic acid1%+ Calcium lactate 1% for 5 min | 72.87 a | 72.67 a | 72.43 a | 70.78 a-e | 69.06 a-d | 71.56 A |
| Calcium lactate1%for5min | 72.87 a | 72.19 a | 71.01 a-c | 69.10 a-d | 63.61 b-f | 69.76 A |
| Control | 72.87 a | 65.06 a-e | 62.86 c-f | 60.67 ef | 56.33 f | 63.56 C |
| Mean | 72.87 A | 71.44 AB | 68.84 BC | 66.74 C | 64.33 D | |

**Values with the same letter(s) are not significantly different at P≤ 0.05 level; using Tukey's multiple range test.**

**Table 6. Effect of some antioxidant agents on a value of fresh cut taro during cold storage at 4° C in 2019 and 2020 seasons.**

| Treatments | Storage period | | | | | |
|---|---|---|---|---|---|---|
| | 2019 | | | | | |
| | **0** | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.50 g | 3.35 b-g | 4.20 b-g | 4.58 b-f | 5.42 a-f | 3.61 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.50 g | 2.65 c-g | 4.08 b-g | 5.51 a-f | 5.75 a-e | 3.70 B |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.50 g | 2.68 c-g | 4.42 b-f | 4.79 a-e | 6.35 a-c | 3.95 B |
| Salicylic acid 1%+Calcium lactate 1% for 5 min | 0.50 g | 1.83 fg | 2.17 e-g | 2.85 c-g | 3.60 b-g | 2.19 C |
| Calcium lactate 1% for 5 min | 0.50 g | 2.44 d-g | 3.36 b-g | 4.45 b-f | 5.86 a-e | 3.32 BC |
| Control | 0.50 g | 4.33 b-g | 6.06 a-d | 6.86 ab | 8.53 a | 5.26 A |
| Mean | 0.50 D | 2.88 C | 4.05 B | 5.01 AB | 5.92 A | |
| Treatments | 2020 | | | | | |
| | 0 | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 2.20 e-h | 2.55 e-h | 3.04 d-h | 3.83 e-g | 4.81 b-f | 3.29 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 2.20 e-h | 2.74 f-h | 3.90 c-g | 4.99 b-e | 6.90 ab | 3.95 B |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 2.20 e-h | 2.45 e-h | 3.83 c-g | 4.58 b-c | 6.21 a-c | 3.86 B |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 2.20 e-h | 2.01 gh | 2.56 e-h | 2.66 f-h | 4.23 b-g | 2.34 C |
| Calcium lactate1%for 5 min | 2.20 e-h | 2.55 e-h | 3.04 d-h | 2.20 e-h | 3.49 c-h | 2.33 C |
| Control | 2.20 e-h | 4.99 b-e | 5.74 a-d | 6.87 ab | 7.87 a | 5.93 A |
| Mean | 2.20 D | 2.28 D | 3.40 C | 4.27 B | 5.58 A | |

**Values with the same letter(s) are not significantly different at P≤ 0.05 level; using Tukey's multiple range test.**

**Texture**

Data in Table 7 indicated that texture decreased continuously with extending the storage period during the two seasons. Similar results were obtained by Chang and Kim (2015) on fresh cut taro. In general, the Texture of vegetables depends on primarily turgidity and the weight loss. In other words, softening is partly due to turgor loss, starch degradation, and chemical modifications in the cell wall (Ramana *et al*., 2011).

Regarding the effect of some antioxidant treatments, data revealed that salicylic acid and ascorbic acid in combination with calcium lactate or calcium lactate alone treatments gave the highest mean values of fruit texture as compared with the other treatments and untreated control with no significant different between them in the first season, followed by cysteine and citric acid in combination with calcium lactate with no significant different between them in the two seasons. The lowest mean values of texture was obtained from the untreated control. These results were true in the two seasons and agree with Ouzounidou *et al*. (2012) for ascorbic acid; Saleh *et al*. (2013) for cysteine or ascorbic acid or citric acid and Attia (2014) for calcium lactate.

The effect of calcium lactate could be due to that the calcium maintains the cell wall structure in fresh cut by interacting with pectin in the cell wall to form calcium pectate which assists molecular bonding between constituents of cell wall. Calcium also, increases cell wall turgor pressure and stabilizers the cell membrane (Luna-Guzman and Barrett, 2000).

The interaction among antioxidant treatments and storage periods on texture seemed to be not significant, in both seasons. However, fresh cut taro treated with salicylic acid in combination with calcium lactate was the most obvious in maintaining the fruit texture during storage in the two seasons, whereas; the lowest values of fruit texture were obtained from the untreated control.

**Table 7. Effect of some antioxidant agents on texture (g/cm$^2$) of fresh cut taro during cold storage at 4° C in 2019 and 2020 seasons.**

| Treatments | Storage period (days) | | | | | |
|---|---|---|---|---|---|---|
| | 2019 | | | | | |
| | **0** | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 8.27a | 7.27 a-d | 6.74 c-e | 6.53 c-f | 6.13 d-g | 7.00 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 8.27 a | 7.22 a-d | 6.88 b-e | 6.58 c-e | 6.14 d-g | 7.02 B |
| Ascorbic acid 1%+Calcium lactate 1% for 5 min | 8.27 a | 7.40 a-d | 7.16 a-e | 6.98 b-e | 6.44 c-f | 7.25 AB |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 8.27 a | 8.03 ab | 7.50 a-c | 7.22 a-d | 7.08 a-e | 7.62 A |
| Calcium lactate1%for5 min | 8.27 a | 7.67 a-c | 7.22 a-d | 7.04 a-e | 6.75 c-e | 7.39 AB |
| Control | 8.27 a | 5.93 e-g | 5.27 f-h | 5.00 gh | 4.48 h | 5.79 C |
| Mean | 8.27 A | 7.25 B | 6.80 C | 6.55 C | 6.20 D | |
| Treatment | 2020 | | | | | |
| | 0 | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 8.28 a | 6.78 a-e | 6.16 b-f | 5.45 d-h | 5.13 e-h | 6.36 C |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 8.28 a | 7.08 a-d | 6.22 b-f | 5.58 c-g | 5.28 e-h | 6.49 C |
| Ascorbic acid 1%+Calcium lactate 1% for 5 min | 8.28 a | 7.30 a-c | 6.42 b-f | 5.83 c-g | 5.78 c-g | 6.72 BC |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 8.28 a | 7.75 ab | 7.18 a-d | 6.80 a-e | 6.62 a-f | 7.33 A |
| Calcium lactate1%for5 min | 8.28 a | 7.65 ab | 6.78 a-e | 6.42 b-f | 6.28 b-f | 7.08 AB |
| Control | 8.28 a | 5.55 c-g | 4.98 f-h | 4.28 gh | 3.72 h | 5.36 D |
| Mean | 8.28 A | 7.02 B | 6.29 C | 5.73 D | 5.47 D | |

**Values with the same letter(s) are not significantly different at P≤ 0.05 level; using Tukey's multiple range test.**

**Polyphenol Oxidase Activity (PPO)**

Data in Table 8 indicated that PPO activity was increased with the prolongation of storage period, in the two tested seasons. The increase of PPO activity after cutting is mainly due to activation process from latent to fully active form. Tissue wounding involves the decompart metallization of cellular components with the subsequent release of proteases involving a cascade of reactions leading to the activation of latent PPO. That PPO enzyme activity increase when fruit is cut and that the activity of phenols was closely associated with the development of browning, these results are in an agreement with reported by Attia ( 2014).

**Table 8. Effect of some antioxidant agents on polyphenol oxidase activity (Unit/g F.W) of fresh cut taro during cold storage at 4° C in 2019 and 2020 seasons.**

| Treatments | Storage period (days) | | | | | |
|---|---|---|---|---|---|---|
| | 2019 | | | | | |
| | **0** | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.020 h | 0.054 d-g | 0.057 c-g | 0.073 b-e | 0.097 b | 0.060 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.020 h | 0.051 e-h | 0.053 e-g | 0.068 b-f | 0.088 bc | 0.056 BC |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.020 h | 0.045 e-h | 0.048 e-h | 0.065 c-g | 0.085 b-d | 0.053 B-D |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 0.020 h | 0.041 f-h | 0.046 e-h | 0.059 c-g | 0.069 b-f | 0.047 CD |
| Calcium lactate 1% for 5 min | 0.020 h | 0.034 gh | 0.040 f-h | 0.054 d-g | 0.066 b-g | 0.043 D |
| Control | 0.020 h | 0.060 c-g | 0.069 b-f | 0.150 a | 0.179 a | 0.096 A |
| Mean | 0.020 D | 0.047C | 0.052C | 0.078 B | 0.097 A | |
| Treatments | 2020 | | | | | |
| | 0 | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.041 h | 0.079 c-g | 0.084 c-f | 0.088 b-f | 0.102 bc | 0.079 B |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.041 h | 0.077 c-g | 0.078 c-g | 0.084 c-f | 0.097 b-d | 0.076 BC |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.041 h | 0.064 e-h | 0.069 d-h | 0.075 c-g | 0.092 b-e | 0.068 CD |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 0.041 h | 0.061 f-h | 0.065 e-h | 0.071 d-g | 0.078 c-g | 0.063 D |
| Calcium lactate1% for5 min | 0.041 h | 0.053 gh | 0.062 f-h | 0.067 e-h | 0.075 c-g | 0.060 D |
| Control | 0.041 h | 0.116 b | 0.162 a | 0.165 a | 0.190 a | 0.135 A |
| Mean | 0.041 D | 0.075 C | 0.087 B | 0.092 B | 0.106 A | |

**Values with the same letters are not significantly different at P≤ 0.05 level; Tukey's multiple range test.**

Concerning the effect of antioxidant agent treatments, data revealed that fresh-cut taro dipped in calcium lactate and salicylic acid or ascorbic acid in combination with calcium lactate were the most effective treatments in reducing PPO activity with no significant differences among them, in both seasons. The highest mean values of PPO activity were obtained from untreated control, in the two seasons. These results are in an agreement with those obtained by Attia (2014) for calcium lactate and Gad El-Rab (2019) for salicylic acid and calcium lactate.

The main function of calcium lactate is strengthened the cell wall and stabilized the cell membrane (Luna-Guzman and Barrett, 2000), thus keeps PPO, which is membrane bound enzyme, away from its phenolic substrates present mainly in vacuoles leading to preserving phenolic content and inhibiting browning process (Huanga *et al*., 2012).

Regarding the interaction between antioxidant agents and storage periods, data revealed that all treatments reduced PPO activity with no significant differences among them compared with the untreated control after 12 days of storage, in the two seasons.

**Total Microbial Count (TMC)**

Data in Table 9 indicated that microbial growth in fresh-cut taro, was significantly, increased with the prolongation of storage period particularly, in the untreated control. These results were achieved, in both seasons. Similar results were reported by Aly *et al.* (2017) on fresh cut taro.

**Table 9. Effect of some antioxidant agents on total microbial count (-×$10^3$ CFU/g) of fresh cut taro during cold storage at 4°C in 2019 and 2020 seasons.**

| Treatments | Storage period (days) | | | | | |
|---|---|---|---|---|---|---|
| | 2019 | | | | | |
| | **0** | **3** | **6** | **9** | **12** | **Mean** |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.00 i | 0.08 i | 0.12 i | 0.16 i | 0.23 g-i | 0.12 D |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.00 i | 0.13 i | 0.19 hi | 0.66 ef | 1.18 ab | 0.43 C |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.00 i | 0.20 hi | 0.40 e-i | 0.60 e-h | 1.10 a-d | 0.46 BC |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 0.00 i | 0.06 i | 0.12 i | 0.17 i | 0.20 hi | 0.11 D |
| Calcium lactate 1% for 5 min | 0.00 i | 0.33 f-i | 0.60 e-h | 0.64 f-g | 0.73 c-f | 0.46 BC |
| Control | 0.00 i | 0.33 f-i | 0.41 e-i | 1.13 a-c | 1.50 a | 0.68 A |
| Mean | 0.00 E | 0.22 D | 0.36 C | 0.59 B | 0.82 A | |
| Treatments | 2020 | | | | | |
| | 0 | 3 | 6 | 9 | 12 | Mean |
| Cysteine 1%+Calcium lactate 1% for 5 min | 0.00 j | 0.06 ij | 0.11 ij | 0.20 g-j | 0.30 e-j | 0.14 D |
| Citric acid 1%+ Calcium lactate 1% for 5 min | 0.00 j | 0.03 j | 0.09 ij | 0.56 d-g | 1.09 b | 0.35 C |
| Ascorbic acid1% +Calcium lactate 1% for 5 min | 0.00 j | 0.27 f-j | 0.59 d-f | 0.72 b-d | 1.00 bc | 0.52 B |
| Salicylic acid 1%+ Calcium lactate 1% for 5 min | 0.00 j | 0.05 j | 0.11 ij | 0.13 ij | 0.16 h-j | 0.09 D |
| Calcium lactate 1% for 5 min | 0.00 j | 0.32 e-j | 0.58 d-f | 0.62 d-f | 0.67 c-e | 0.44 BC |
| Control | 0.00 j | 0.43 d-i | 0.51 d-h | 1.53 a | 1.90 a | 0.88 A |
| Mean | 0.00 E | 0.19 D | 0.33 C | 0.63 B | 0.86 A | |

**Values with the same letter(s) are not significantly different at P≤ 0.05 level; using Tukey's multiple range test.**

Concerning the effect of some antioxidant agents' treatments, data revealed that there were significant differences in microorganism growth between all treatments and untreated control. Fresh-cut taro dipped in solution of salicylic acid or cysteine in combination with calcium lactate treatments had the lowest count in all types of microorganisms with no significant different between them in the two seasons, followed by citric acid or ascorbic acid in combination with calcium lactate and calcium lactate with no significant differences between them in the first season. Untreated control recorded the highest levels of microbial load. These results were achieved, in both seasons and were in an agreement with those obtained by Gad El-Rab (2019) for salicylic acid or calcium lactate; Attia (2014) for calcium lactate and Yassin (2016) for cysteine.

Concerning the interaction among antioxidant agents treatments and storage periods, data showed that after 12 days of storage fresh-cut taro dipped in salicylic acid or cysteine in combination with calcium lactate were the most effective treatments in reducing the level of microbial load with no significant differences between them compared with the other treatments, whereas; the untreated control had the highest value of microbial count. These results were achieved, in both seasons.

## CONCLUSION

From the previous results, it could be concluded that fresh-cut taro dipped in salicylic acid at 1% in combination with calcium lactate 1% was the most effective treatment in reducing weight loss percentage, color change of cut surface, total microbial count and PPO activity and maintained quality and gave fresh-cut taro with good appearance after 12 days of storage at 4ºC.

## REFERENCES


Altunkaya, A. and V. Gökmen (2008). Effect of various inhibitors on enzymatic browning, antioxidant activity and total phenol content of fresh lettuce (*Lactuca sativa*). Food Chem., 107:1173-1179.

Aly, S.S.H., E. N. Mohamed and E. S. Abdou (2017). Effect of Edible Coating on Extending the Shelf Life and Quality of Fresh Cut Taro. Research Article. Am. J. Food Technol., 12 (2): 124-131.

Asgharia, M. and M.S. Aghdam (2010). Impact of salicylic acid on post-harvest physiology of horticultural crops. Trends in Food Sci. & Technol., 21:502-509.

Attia, M.M. (2014). Effect of calcium chloride, calcium lactate and hydrogen peroxide treatments on quality of fresh cut cantaloupe during cold storage. Egypt. J. Agric. Res., 92(3):961-978.

Budu, A.S. and D.C. Joyce (2003). Effect of 1-methylcyclopropene on the quality of minimally processed pineapple fruit. Austral. Anim. Prod. Sci., 43:177-184.

Cantwell, M., X. Nie and G. Hong (2009). Impact of storage conditions on grape tomato quality. 6th ISHS Postharvest Symposium, Antalya, Turkey, pp. 8.

Cao, J., Y. Jiaqi, Z. Yumei and J. Weibo (2013). Effects of postharvest salicylic acid dipping on Alternaria rot and disease resistance of jujube fruit during storage. Sci. of food and Agri., pp 3252-3258.

Chang, M. S. and G. H. Kim (2015). Combined Effect of Hot Water Dipping and Vacuum Packaging for Maintaining the Postharvest Quality of Peeled Taro. Hortic. Environ. Biotechnol., 56(5):662-668.

Gad El-Rab, N.A. (2019). Effect of some pre and postharvest treatments on yield, quality and storability of snap beans. . Ph.D. Thesis, Fac. Agric., Cairo Univ., Cairo, Egypt, 252p.

Garcia-Molina, F., M.J. Penalver, J.N. Rodriguez-Lopez, F. Garcia-Canovas and J. Tudela (2005). Enzymatic method with polyphenol oxidase for the determination of cysteine and N-acetylcysteine. J. Agric. Food Chem., 53:6183-6189.

Huanga, S., T. Li, G. Jiangb, W. Xiea, S. Changa, Y. Jiangb and X. Duan (2012). 1-Methylcyclopropene reduces chilling injury of harvested okra (*Hibiscus esculentus* L.) pods. Sci. Hort., 141:42-46.

Ibrahim, R., A. Osman, N. Saari and R.A. Abdul-Rahman (2004). Effect of anti-browning treatments on the storage quality of minimally processed shredded cabbage. J. Food Agric. Environment, 2(2):54-58.

Jang JH, Moon KD. (2011): Inhibition of polyphenol oxidase and peroxidase activities on fresh–cut apple. Food Chemistry 124: 444–449.

Javan, A. J., A. Nikmanesh, K. Keykhosravy, S. Maftoon, M. A. Zare, M. Bayani, M. Parsaiemehr and M. Raeisi. (2015). Effect of Citric Acid Dipping Treatment on Bioactive Components and Antioxidant Properties of Sliced Button Mushroom (*Agaricus bisporus*). Journal of Food Quality and Hazards Control, 2 : 20-25.

Kasim, R., M.U. Kasim and G.E.O. Uyar (2015). Postharvest ascorbic acid treatments on color and sugar changes on fresh-cut carrot. Inter. J. Res. Agric. and Food Sci., 2(10):1-8.

Lamikanra, O. and M. Watson (2007). Mild heat and calcium treatment effects on fresh–cut cantaloupe melon during storage. Food Chemistry, 102: 1383–1388.

Lee, M.Y., M.K. Lee and I. Park (2007). Inhibitory effect of onion extract on polyphenol oxidase and enzymatic browning of taro (*Colocasia antiquorum var. esculenta*). Food Chem., 105:528-532.

Luna-Guzman, I. and D.M. Barrett (2000). Comparison of calcium chloride and calcium lactate effectiveness in maintaining shelf stability and quality of fresh-cut cantaloupes. Postharvest Biol. Technol., 19:61–72.

Marshall, S. (1992). Standard Methods for Examination of Dairy Products American public Health Association (APHA). Washington DC, USA.

Martin-belloso, O., R. Soliva-fortuny and G. Oms-Oliu. (2007). Fresh- Cut Fruits, In: Hui YH (ed.), Handbook of Food Products Manufacturing. Principles, Bakery, Beverages, Cereals, Cheese, Confectionary, Fats, Fruits, and Functional Foods. John Wiley and Sons, New Jersey. pp879-899.

MC Guire, R. G. (1992). Reporting of objective color measurements. Hort-Science 27: 1254-1255.

Mohamed, A. Y. I., H. El- D. Aboul-Anean and A. S.H. Atress (2015). Effect of anti-browning agents and gelatin coating on browning inhibition and shelf life of minimally processed eggplant during storage. Egypt . J. of Appl. Sci., 30 (9): 178-189.

Ouzounidou, G., M. Asfi and F. Gaitis (2012). Postharvest application of various chemical factors and their effects on quality characteristics and microbial load of raw beans (*Phaseolus vulgaris* L.). Acta Alimentaria, 41(3):363-374.

Pizzocaro, F., D. Torregiani and G. Gilardi (1993). Inhibition of apple polyphenoloxidase (PPO) by ascorbic acid, citric acid and sodium chloride. Food Process Preservation, 17: 21–30.

Ramana Rao, T.V., B.G. Neet, and K.S. Khilana, (2011): Effect of postharvest treatments and storage temperatures on the quality and shelf life of sweet pepper (*Capsicum annum* L.). Sci. Hortic. 132:18-26.

Rico, D., A.B. Martin-Diana, J.M. Barat and C. Barry-Ryan (2007). Extending and measuring the quality of fresh-cut fruit and vegetables: A review. Trends Food Sci. Technol., 18: 373-386.

Risse, R.A. and W.R. Miller. (1986). Individual film wrapping of fresh Florida cucumbers, eggplant, peppers and tomatoes for extending shelf life. J. Plastic Film & Sheeting, 2:164-171.

Saleh, M.A., A.M. El-Gizawy, R.E.L. El-Bassiouny and H.M. Ali (2013). Effects of anti-coloring agents on blackening inhibition and maintaining physical and chemical quality of fresh-cut okra during storage. Annals of Agric. Sci., 58(2):239-245.

Siomos, A.S., D. Gerasopoulos, P. Tsouvaltzis and A. Koukounaras. (2010). Effects of heat treatment on atmospheric composition and color of peeled white asparagus in modified atmosphere packaging. Innovative Food Sci. Emerg. Technol., 11:118-122.

Snedecor, G.W. and W.G. Cochran (1980). Statistical Method. 7th Edn., Iowa State University Press, Ames, Iowa, USA., pp 507.

Suttirak, w. and Manurakchinakorn, S. (2010). Potential application of ascorbic acid, citric acid and oxalic acid for browning inhibition in fresh-cut fruits and vegetables. walailak J. Sci. Tech. 7(1):5-14.

Vasey, C. (2006). The Water Prescription: For Health, Vitality, and Rejuvenation. United States: Healing Arts press, March 20, Publication Date: October 5, 2010.

Yassin, N. M. (2016). Effect of chemical preservation on browning and keeping quality of fresh cut apple slices during cold storage. Inter. J. Chem. Tech. Res., 9(10): 211-217.

Zheng, Y. and Q. Zhang. (2004). Effects of polyamines and salicylic acid postharvest storage of 'Ponkan' mandarin. Acta Hort., 632: 317-320.

## تأثير بعض مضادات الاكسدة على خصائص الجودة والقدرة التخزينية للقلقاس المقطع جزئياً

**منى منتصر حافظ[1] ، سامية سامى عبد الواحد القلينى[2] وامانى حافظ عبد الله محمود غريب [3]**

**[1]قسم بحوث تداول الخضر - معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر.**

**[2] قسم بحوث تداول الخضر- معهد بحوث البساتين – مركز البحوث الزراعية – الصبحية - اسكندرية – مصر.**

**[3]قسم تربية النباتات الطبية والعطرية - معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر.**

اجريت هذه الدراسة خلال موسمى 2019، 2020 بمعمل قسم بحوث تداول الخضر - معهد بحوث البساتين – مركز البحوث الزراعية –الجيزة – مصر على محصول القلقاس والذى تم حصاد من مزرعة بحوث الخضر بالقناطر الخيرية- محافظة القليوبية بهدف دراسة تاثير بعض معاملات ما بعد الحصاد (سيستين، حمض الستريك، حمض الاسكوربيك، حمض السالسيلك) بتركيز 1% مع لاكتات الكالسيوم1% ولاكتات الكالسيوم 1% منفردة وذلك مقارنة بالكنترول (المعاملة بالماء المقطر) للمحافظة على خصائص الجودة فى القلقاس المقطع جزئيا واطالة فترة العرض بالاسواق. اوضحت النتائج ان جميع المعاملات حافظت على خصائص الجودة مقارنة بالغير معاملة (الكنترول) خلال جميع فترات التخزين وان غمس القلقاس المقطع جزئيا فى حمض السالسيلك 1% مع لاكتات الكالسيوم 1% لمدة 5 دقائق وكذلك لاكتات الكالسيوم منفردة 1% لمدة 5 دقائق اكثر المعاملات تاثيرا فى تقليل الفقد فى كلا من الوزن والصلابة كما حافظت هذه المعاملات على الجودة المظهرية وادت الى تثبيط التدهور فى سطح القطع واعطت اقل مستوى من الحمل الميكروبى واقل نشاط لانزيم البولى فينول اوكسيديز وذلك مقارنة بباقى المعاملات خلال التخزين على درجة 4°م و95% رطوبة نسبية لمدة 12يوم.