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Studies of Salicylic Acid and Chitosan on Storage Ability of "Solar Eclipse" Plum Fruits

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ABSTRACT

This study evaluated the effects of postharvest treatments with salicylic acid and chitosan at different concentrations on the quality of "Solar Eclipse" plum fruits during storage. The experiment was conducted over two seasons (2024–2025) using trees grown under sandy soil and drip irrigation systems, involved five treatments: salicylic acid at (0.5% and 1.0%), chitosan at (1.0% and 2.0%), and the control. Fruits were stored at 4 ± 1°C with 90–95% relative humidity and assessed after 15 and 30 days of cold storage and a subsequent three days as a shelf life at room temperature to assess the changes in physio-chemical properties under ambient conditions. All studied treatments significantly affected weight loss, maintained firmness, soluble solids content and anthocyanin content. All applied treatments reduced the loss in fruit weight than the control. Since, the percentage of loss in fruit weight of the untreated fruits was (٦،٥٠% and 5.21%) after 30 days of cold storage. Yet, dipping Solar Eclipse plum fruits in salicylic acid at 1.0% significantly reduced the loss in fruit weight since it ranged about (4.91% and 4.77%) after 30 days under cold storage during the two seasons. Also, dipping the fruits in chitosan at 1% or 2% presented a lower value than the untreated ones. Chitosan and salicylic positively affected the most quality traits.

Keywords: Plum, Solar-Eclipse, Postharvest, Salicylic, Chitosan

INTRODUCTION

Plum (*Prunus domestica*) is one of fruit with high economic and nutritional value, rich in vitamins, minerals, and phenolic compounds with antioxidant properties. In Egypt, the total cultivated area of plums covers approximately 3000 fed, with an annual production of 14,237ton, according to the Ministry of Agriculture and Soil Reclamation (2022). These figures highlight the significance of plum cultivation as a vital component of Egyptian horticulture, contributing to both domestic consumption and export potential. However, improving the storage ability of plum fruits remains crucial to maximizing their market value and reducing post-harvest.

Solar Eclipse is considered one of the new plum cultivars has been introduced to Egypt. This cultivar is distinguished by its high quality and exceptional characteristics in terms of taste and nutritional value, making it a promising addition to enhance productivity and competitiveness in both local and international markets.

Storage is one of the major challenges facing marketing of plums, as they are highly perishable due to weight loss, changes in color, firmness, sugar and acid content. Therefore, it is essential to employ modern techniques to improve fruit quality and extend its shelf life (Arion *et al.* 2014).

Chitosan is a natural polymer derived from chitin, a primary component of the exoskeletons of crustaceans and cell walls of fungi (Casquero, ٢٠٠٩). Chitosan chemically is a linear polysaccharide composed of β-(1→4)-linked D-glucosamine and N-acetyl-D-glucosamine allows it to form films and coatings with excellent biocompatibility, biodegradability, and antimicrobial properties. These properties enable chitosan to create a protective barrier on fruit surfaces, reducing water loss and delaying physiological and chemical changes. This effect helps maintain firmness, natural color, and overall quality during storage. Furthermore, chitosan is an environmentally friendly and non-toxic material, making it a safe alternative to traditional chemical treatments (El-Eleryan, 2015; Kumar *et al.* 2017).

Salicylic acid (SA) is a naturally occurring phenolic compound with the chemical formula C_6H_4 (OH) COOH. This simple effective structure plays a key role in modulating various physiological processes in plants. A.s a postharvest treatment, salicylic acid functions by reducing the activity of enzymes responsible for fruit deterioration, such as polyphenol oxidase and peroxidase. It also enhances the fruit's antioxidant defense system, improving its response to oxidative stress. Additionally, salicylic acid helps maintain a balance between sugars and organic acids, contributing to the preservation of fruit flavor and quality during storage (Davarynejad *et al.* 2015).

This study aims to evaluate the effect of postharvest treatments with chitosan and salicylic acid at different concentrations on improving the quality of "Solar Eclipse" plum fruits during storage. The study seeks to identify the best treatments that help preserving the physical and chemical characteristics of the fruits, reduce deterioration rates, extend shelf life, and enhance market value.

MATERIALS AND METHODS

The experiment was conducted during the two successive seasons of 2024 and 2025 on Plum (*Prunus domestica* cv. Solar Eclipse) grown under sandy soil conditions

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with a drip irrigation system, The plum fruits were harvested on July from a private farm located at Alexandria-Cairo Desert Road. Immediately after harvesting, fruits were transported to the Laboratory of Pomology Department. Faculty of Agriculture, Mansura University.

1. Fruit Sorting and Preparation

Upon arrival at the laboratory, the fruits were carefully sorted to exclude damaged or mechanically injured fruits. The experimental design followed a completely randomized design (CRD) with five treatments. The selected fruits were then divided into five groups, and each group was subjected to one of the following treatments by dipping the fruits in the respective solutions for 10 minutes:

- Salicylic acid at a concentration of 0.5 %.
- Salicylic acid at a concentration of 1.0 %.
- Chitosan at a concentration of 1.0 %.
- Chitosan at a concentration of 2.0 %.
- Control (tap water).

After treatments, the fruits were air-dried and packed into well-ventilated plastic bags. Each bag was weighed, and five bags were placed in a well-ventilated box measuring 50 × 30 × 12 cm. Each treatment consisted of four boxes, with each box containing five plastic bags.

2. Cold Storage and Sampling Intervals

The packed fruits were stored at a temperature of 4 ± 1°C with a relative humidity of 90–95%. Sampling was conducted at two storage intervals, 15 and 30 days, during which two boxes were taken from each treatment:

One box was analyzed to evaluate the chemical and physical quality parameters of the fruits during cold storage and the other box was transferred to room temperature (25 ± 2°C) for three days to assess the changes in physio-chemical properties under ambient conditions.

Additionally, fruit sample was analyzed before storage to be the initial. This approach provided insights into the immediate and long-term effects of the treatments on the storage ability and quality of plum fruits.

3. Measurements

Fruit weight loss percentage: The percentage of weight loss for each bag was determined relative to its initial weight using the following formula:

$$\text{Weight Loss } (\%) = \left(\frac{W_{\text{initial}} - W_{\text{sample}}}{W_{\text{initial}}} \right) \times 100$$

Where,

W initial: Initial weight of the fruit (g).

W sample: Weight of the fruit at the sampling date (g).

Decay percentage: Decay percentage was determined by weighing the decayed fruits in each sample during storage. The percentage was calculated using the following formula:

$$\text{Decay Percentage } (\%) = \frac{\text{Weight of Decayed Fruits}}{\text{Initial Fruit Weight}} \times 100$$

Total fruit weight loss percentage: The total loss in fruit weight percentage was calculated by combining the percentage of weight loss and the percentage of decayed fruits using the following formula:

$$\text{Total Loss in Weight } (\%) = \text{Loss in Fruit Weight } (\%) + \text{Decay Percentage } (\%)$$

Fruit firmness (lb/in²): The flesh firmness of fruits for each treatment was measured using a hand Effegi penetrometer equipped with an 8 mm plunger tip. The results were recorded and expressed in (lb/in^2), according to Tzoutzoukou and Bouranis (1997).

Soluble solids content (SSC %) in fruit juice was measured using a hand refractometer, following the procedure of Chen and Mellenthin (1981).

Total titratable acidity (%): A 10 mL sample of fruit juice was titrated against 0.1 N NaOH using phenolphthalein as the endpoint indicator. The acidity was calculated and expressed as grams of malic acid per 100 mL juice, according to the method recommended by A.O.A.C. (2006).

SSC/acid ratio: The ratio of soluble solids to titratable acidity was computed by dividing SSC values by the corresponding acidity values.

Total anthocyanin content (mg/100 g FW): Anthocyanin concentration in the fruit skin was quantified according to the procedure described by Hsia *et al.* (1965).

4. Statistical Analysis

The collected data were subjected to statistical analysis using SAS software Statistical comparisons among treatments were performed using one-way analysis of variance (ANOVA), followed by the least significant difference (LSD) test at a 0.05 probability level to determine significant differences (Gomez and Gomez, 1984).

RESULTS AND DISCUSSIONS

1- Loss weight percentage:

Data presented in Tables (1 and 2) illustrate the changes in weight loss of Solar Eclipse plum fruits during cold storage and subsequent exposure to room temperature (as a shelf life treatment).

Table 1. Effect of salicylic acid and chitosan on fruit weight loss percentage under cold storage and shelf life (2024 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0. 5%	0.00	3.59	٦,٠١	3.٢٠	0.00	6.48	٧,٩٤	4.٨٠
Salicylic acid at 1.0 %	0.00	2.89	٤,٩١	2.٦٠	0.00	5.09	٧,٦٥	4.٢٤
Chitosan acid at 1.0 %	0.00	2.61	5.99	2.63	0.00	6.55	8.40	4.٩٨
Chitosan acid at 2.0 %	0.00	2.65	5.27	2.٦٤	0.00	5.64	٨,٤٠	4.٦٨
Control (Tap water)	0.00	4.11	٦,٥٠	3.٥٣	0.00	7.38	٩,٠٥	٥,٤٧
Mean	0.00	3.17	5.73	—	0.00	6.23	8.22	—
LSD at 5%	Treatments (T) = 0.70 Storage (S) =0.44 T x S =1.00				Treatments (T) = 1.56 Storage (S) =0.99 T x S =2.22			

Table 2. Effect of salicylic acid and chitosan on fruit weight loss percentage under cold storage and shelf life (2025 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0. 5%	0.00	3.09	5.05	2.76	0.00	5.99	9.11	5.03
Salicylic acid at 1.0 %	0.00	2.46	4.77	2.4١	0.00	6.00	٨,٠٢	٤,٦٧
Chitosan acid at 1.0 %	0.00	2.11	5.07	2.39	0.00	6.31	8.64	4.98
Chitosan acid at 2.0 %	0.00	2.11	٤,٩٤	2.١٨	0.00	5.90	٩,٠٠	4.٩٦
Control (Tap water)	0.00	3.68	5.21	2.96	0.00	6.17	9.07	5.08
Mean	0.00	2.69	5.01	—	0.00	6.07	8.76	—
LSD at 5%	Temperature (T) = 0.34 Storage (S) =0.21 T x S =0.48				Temperature (T) =0.50 Storage (S) =0.31 T x S =0.71			

Results showed a progressive increase in fruit weight loss as the storage duration advanced, either under cold conditions or at room temperature. However, all postharvest treatments effectively minimized weight loss compared with the untreated control. In particular, the percentage of weight loss in the control fruits reached 6.50% and 5.21% after 30 days of cold storage during the 2024 and 2025 seasons, respectively. Conversely, dipping fruits in 1.0% salicylic acid markedly decreased weight loss, recording 4.91% and 4.77% after 30 days of cold storage in the two respective seasons. Similarly, treatments with chitosan at 1% or 2% consistently resulted in lower weight loss values compared with untreated fruits across both seasons.

Concerning, the effect of treatments on fruit weight losses after shelf life, the presented data clarify that it increased as the storage period advanced.

After shelf life, fruits of control treatment exhibited the highest weight loss %, while treatments with salicylic acid at 1.0% gave the lowest weight loss (7.65% – 8.02%) during 3 days of shelf life after 30 days of cold storage.

In this respect, Salicylic Acid: natural compound is known for its ability to delay senescence and enhance the stress tolerance of fruits by reducing respiration and transpiration rates. The high storage temperature causes a high respiration rate which lead to a fruit weight loss. (Awad, 2013; Davarynejad *et al.* 2015).

Due to its pivotal involvement in regulating photosynthesis, maintaining plant water balance, modulating enzymatic functions, and enhancing tolerance to both biotic and abiotic stresses, salicylic acid has been recognized as an important signaling molecule. Exogenous application of salicylic acid has proven effective in promoting plant growth and improving crop productivity under fluctuating environmental conditions (Senaratna *et al*., 2000, Horvath *et al*., 2007; Hayat *et al*., 2010)

The effectiveness of salicylic acid in minimizing weight loss is consistent with findings by Luo *et al.* (2011), who presented its role in enhancing postharvest quality. Similarly, the performance of chitosan aligns with earlier studies (Bal, 2013), which emphasized its role in forming moisture-retentive coatings and its antifungal properties.

2- Decay percentage:

It is clear from Tables 3, 4 that all treatments inhibit the decay of fruits significantly after 30 days of cold storage during both seasons. Yet, dipping Solar Eclipse plum fruits in salicylic acid 1.0% significantly decreased decay percentage during 3 days of shelf life after 30 days of cold storage in seasons 2023 and 2024. than the other treatments used or the control.

Table 3. Effect of salicylic acid and chitosan on fruit decay percentage under cold storage and shelf life (2024 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0. 5%	0.00	0.00	0.00	0.00	0.00	0.00	5.19	1.73
Salicylic acid at 1.0 %	0.00	0.00	0.00	0.00	0.00	0.00	4.69	1.56
Chitosan acid at 1.0 %	0.00	0.00	0.00	0.00	0.00	1.00	6.71	2.36
Chitosan acid at 2.0 %	0.00	0.00	0.00	0.00	0.00	1.83	6.10	2.84
Control (Tap water)	0.00	1.11	2.35	1.15	0.00	2.23	8.33	3.52
Mean	0.00	0.22	0.47	—	0	1.013	6.20	—
LSD at 5%	Treatments (T)= 0.20 Storage (S) = 0.11 T x S = 0.29				Treatments (T) = 0.42 Storage (S) = 0.26 T x S = 0.59			

Table 4. Effect of salicylic acid and chitosan on fruit decay percentage under cold storage and shelf life (2025 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0. 5%	0.00	0.00	0.00	0.00	0.00	1.34	4.48	1.94
Salicylic acid at 1.0 %	0.00	0.00	0.00	0.00	0.00	0.00	4.11	1.37
Chitosan acid at rate of 1.0 %	0.00	0.00	0.00	0.00	0.00	0.79	4.42	3.07
Chitosan acid at rate of 2.0 %	0.00	0.00	0.00	0.00	0.00	0.00	4.23	1.41
Control (Tap water)	0.00	0.00	1.77	0.59	0.00	0.00	8.99	1.37
Mean	0.00	0.00	0.35	—	0	0.42	5.07	—
LSD at 5%	Treatments (T) = 0.11 Storage (S) = 0.12 T x S = 0.16				Temperature (T) = 0.39 Storage (S) = 0.25 T x S = 0.56			

Since, it presented 4.69 and 4.11 % decayed fruits, while fruits of control record 8.33 and 8.99 % after the same period. However, fruits treated with chitosan at 1.0% exhibited lower decay percentages, than untreated fruits suggesting that the concentration plays a critical role in optimizing decay prevention. The data obtained indicate a potential antimicrobial effect of chitosan and are in agreement with data reported for plums (Dang et al., 2010; Chiabrando and Giacalone, 2016; Bal, 2013; Tokatlı and Demirdöven, 2020).

These results can be attributed to the functional properties of the applied materials. Salicylic acid functions as a plant growth regulator with antioxidant and antimicrobial properties, reducing the likelihood of decay by inhibiting microbial growth on the fruit surface (Shaarawi *et al.* 2016; El-Khalek *et al.* 2018; Batool *et al.* 2022; Hajiesmaeili and Danaee, 2024).

3. Total loss in weight percentage

Tables 5,6 point out the impact of salicylic acid and chitosan applied at different concentrations on the total weight loss percentage of fruits during cold storage and subsequent shelf life at room temperature during 2024 and 2025 seasons. Across both seasons, total weight loss increased consistently with longer storage durations, both under cold storage and during the shelf life period. The treatments exhibited variable performance, with salicylic acid and chitosan reducing weight loss compared to the control.

The data reveal that treatments with salicylic acid and chitosan treatments effectively minimized total weight loss compared to the control. Since, salicylic acid at 1.0% (4.91–4.77) emerged as the most consistent treatment in reducing weight loss across storage durations,during the shelf life period, weight loss percentages increased significantly, but treated fruits still exhibited lower losses compared to untreated fruits, dipping Solar Eclipse plum fruits in salicylic acid 1.0% (12.34–12.13) significantly increased decay percentage during 3 days of shelf life after 30 days of cold storage in seasons 2024 and 2025 comparing with the control (17.38– 18.06) These findings highlight the efficacy of the treatments in maintaining fruit quality during storage.

The observed trends can be attributed to the physiological and biochemical properties of both salicylic acid and chitosan. Salicylic acid is known for its role in enhancing stress tolerance and reducing water loss by regulating stomatal closure and maintaining cell membrane integrity. The higher concentration (1.0%) proved more effective due to its stronger influence on these processes. While, chitosan creates a semi-permeable barrier on the fruit surface, reducing water evaporation and delaying weight loss. The performance of chitosan at 2.0% reflects its ability to provide a thicker and more effective coating compared to the lower concentration.

The increase in weight loss over time is a natural consequence of fruit respiration and transpiration during storage. Treated fruits exhibited reduced weight loss due to the physiological modifications induced by salicylic acid and the protective coating provided by chitosan. The control, lacking such interventions, demonstrated the highest weight loss as a result of unregulated transpiration and respiration. ((Triunfo et al. 2023; Hajiesmaeili and Danaee, 2024; Korićanac et al. 2024).

Table 5. Effect of salicylic acid and chitosan on fruit total weight loss percentage under cold storage and shelf life (2024 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	0.00	3.59	6.01	3.20	0.00	8.31	13.13	7.14
Salicylic acid at 1.0%	0.00	2.89	4.91	2.60	0.00	5.09	12.34	5.81
Chitosan acid at 1.0%	0.00	2.61	5.99	2.86	0.00	7.55	15.11	7.55
Chitosan acid at 2.0%	0.00	2.65	5.27	2.64	0.00	7.47	14.50	7.32
Control (Tap water)	0.00	5.22	8.85	4.69	0.00	9.61	17.38	11.40
Mean	0.00	3.39	6.20	—	0.00	7.24	15.93	—
LSD at 5%	Treatments (T)=0.709 Storage (S)=0.448 TxS=1.003				Treatments (T)=1.748 Storage (S= 1.105 TxS=2.472			

Table 6. Effect of salicylic acid and chitosan on fruit total weight loss percentage under cold storage and shelf life (2025 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	0.00	3.09	5.05	2.76	0.00	7.33	13.59	6.97
Salicylic acid at 1.0%	0.00	2.46	4.77	2.41	0.00	6.00	12.13	6.04
Chitosan acid at 1.0%	0.00	2.11	5.07	2.39	0.00	7.10	13.06	8.05
Chitosan acid at 2.0%	0.00	2.11	4.94	2.35	0.00	5.90	13.23	6.37
Control (Tap water)	0.00	3.68	6.98	3.55	0.00	7.51	18.06	7.19
Mean	0.00	2.69	5.36	—	0.00	6.34	14.01	—
LSD at 5%	Treatments (T)=0.344 Storage (S)=217 TxS=0.487				Treatments (T)=0.703 Storage (S)=0.445 TxS=0.995			

4- Fruit firmness of plum fruits:

Firmness, a critical quality attribute, decreased with storage time across all treatments and both seasons, with treated fruits generally maintaining higher firmness compared to the control according to tables 7,8.

Table 7. Effect of salicylic acid and chitosan on fruit firmness (Nlb/in²) under cold storage and shelf life (2024 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	٨,٧٥	7.47	7.34	7.85	٨,٧٥	7.48	5.21	7.14
Salicylic acid at 1.0%	٨,٧٥	8.78	8.22	8.58	٨,٧٥	8.03	5.77	7.52
Chitosan acid at 1.0%	٨,٧٥	8.94	8.25	8.65	٨,٧٥	7.95	5.27	7.32
Chitosan acid at 2.0%	٨,٧٥	7.71	8.08	8.18	٨,٧٥	7.68	5.54	7.32
Control (Tap water)	٨,٧٥	8.42	7.69	8.29	٨,٧٥	7.77	5.11	7.21
Mean	8.75	8.26	7.92	—	8.75	7.78	5.38	—
LSD at 5%	Treatments (T)=0.300 Storage (S)=0.181 TxS=0.424				Treatments (T)=0.253 Storage (S)=0.160 TxS=0.357			

Table 8. Effect of salicylic acid and chitosan on fruit firmness (lb/in²) under cold storage and shelf life (2025 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	7.86	7.86	7.76	7.82	7.86	7.74	5.41	7.00
Salicylic acid at 1.0%	7.86	7.80	7.61	7.76	7.86	7.48	5.73	7.02
Chitosan acid at 1.0%	7.86	7.56	7.05	7.49	7.86	6.29	4.28	6.14
Chitosan acid at 2.0%	7.86	7.68	7.53	7.69	7.86	7.61	5.38	6.95
Control (Tap water)	7.86	7.80	7.68	7.78	7.86	7.33	5.60	6.93
Mean	7.86	7.74	7.52	—	7.86	7.29	5.28	—
LSD at 5%	Treatments (T)=0.115 Storage (S)=0.072 TxS=0.163				Treatments (T)=0.094 Storage (S)=0.060 TxS=0.006			

In this context, the results indicated that all applied treatments significantly minimized the reduction in fruit firmness compared with the control, whether during cold storage or subsequent exposure to room temperature across both seasons. Nevertheless, the decline in firmness was more pronounced at room temperature than under cold storage. This outcome is expected, as the higher shelf temperature accelerates the respiration rate, leading to a faster softening of fruits compared with the cooler conditions.

Furthermore, treated Solar Eclipse plum fruits in salicylic acid 1.0% significantly produced higher fruit firmness (8.22 -7.61 lb/inch) after 30 days of cold storage while, it averaged (5.77-5.73 lb/inch) after 3 days of shelf life in the two seasons respectively.

In this respect, the role of salicylic acid in enhancing firmness can be attributed to its capacity to reduce ethylene production and inhibit cell wall-degrading enzymes like pectinase and cellulase. It has been demonstrated that salicylic acid maintains flesh firmness of harvested fruits (Wang *et al*., 2006; Li and Han, 1999; Yan *et al*., 1998)

On the other hand, chitosan, a biopolymer, forms a protective barrier on the fruit's surface, reducing moisture loss and gas exchange. Its antimicrobial properties further contribute to maintaining firmness by limiting microbial activity that accelerates degradation. In plums coated with chitosan, the reduced loss of firmness compared with uncoated fruits may be attributed to the lower production of CO_2, which suppresses the activity of cell wall–degrading enzymes such as polygalacturonase and pectin methyl esterase. These enzymes are primarily responsible for fruit softening, as previously suggested by Manganaris *et al*., (2008).

While a natural decline in firmness over time is expected due to ripening and enzymatic breakdown of structural components, these treatments significantly slow these processes, thereby preserving fruit quality for extended periods. The obtained results are in harmony with those of Luo *et al.* (2011); Davarynejad *et al.* (2015); Kumar *et al.* (2017); Bal, (2013).

5- Soluble solids content (SSC %)

With respect to soluble solids content (SSC), the data presented in Tables (9 and 10) demonstrated a gradual decline in SSC of *Solar Eclipse* plum juice as the storage period extended, both under cold storage and at room temperature.

Table 9. Effect of salicylic acid and chitosan on SSC % in juice fruits under cold storage and shelf life (2024 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	12.65	14.21	16.10	14.32	12.65	15.50	16.00	14.71
Salicylic acid at 1.0%	12.65	14.63	15.00	14.09	12.65	15.50	15.75	14.63
Chitosan acid at 1.0%	12.65	14.00	14.40	13.68	12.65	15.41	15.53	14.53
Chitosan acid at 2.0%	12.65	13.93	14.20	13.59	12.65	14.38	16.50	14.51
Control (Tap water)	12.65	15.53	15.83	14.47	12.65	15.53	16.10	14.76
Mean	12.65	14.46	15.10	—	12.65	15.26	15.97	—
LSD at 5%	Treatments (T)=1.073 Storage (S)=0.678 TxS=1.518				Treatments (T)=0.820 Storage (S)=0.518 TxS=1.159			

Table 10. Effect of salicylic acid and chitosan on SSC (%) in juice fruits under cold storage and shelf life (2025 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	13.11	14.45	15.30	14.28	13.11	14.73	16.00	14.61
Salicylic acid at 1.0%	13.11	14.10	15.47	14.22	13.11	14.00	16.45	14.52
Chitosan acid at 1.0%	13.11	14.40	14.98	14.16	13.11	14.78	15.63	14.50
Chitosan acid at 2.0%	13.11	14.03	14.99	14.04	13.11	14.08	16.20	14.46
Control (Tap water)	13.11	14.90	15.96	14.65	14.11	14.80	16.90	14.93
Mean	13.11	14.37	15.34	—	13.11	14.47	16.23	—
LSD at 5%	Treatments (T)=0.090 Storage (S)=0.057 TxS=0.128				Treatments (T)=0.096 Storage (S)=0.061 TxS=0.137			

These findings are consistent with the observations of Luo et al. (2011), who reported a reduction in SSC of plum fruits with prolonged storage duration. This decline may be attributed to water losses resulting from respiration and evaporation processes during storage. The results indicate that the use of salicylic acid and chitosan helps preserve the SSC in fruits better than the control group. It is also noted that the benefits of these treatments vary from season to season.

The data also disclose that, dipping Solar Eclipse plum fruits in salicylic acid 1.0% gave the highest value of SSC% in fruit juice so, it presented (15.00– 15.47) after 30 days of cold storage while, it averaged (15.75– 16.45) after after 3 days of shelf life in the both seasons respectively.

The retention of SSC in fruits reflects the treatments ability to reduce enzymatic reactions that lead to the degradation of sugars within the fruit. Salicylic acid is known for its role in stress resistance and promoting processes that help preserve quality, while chitosan acts as a physical barrier that reduces moisture loss and gas exchange, which helps in maintaining the internal structure of the fruit. This effect is particularly significant in the agricultural industry, where maintaining fruit quality during storage is essential.

Previous studies have shown that both salicylic acid and chitosan can contribute to improved fruit quality by reducing the loss of soluble solids content during storage, as demonstrated in studies on the effects of various treatments on fruit storage (Davarynejad *et al.* 2015; Kumar *et al.* 2017; Bal, 2013). These findings align with the results observed in this research, where salicylic acid and chitosan treatments improved SSC retention.

6-Total titratable acidity.

Data from Tables 11, 12 presented that the total titratable acidity in juice of plum fruits decreased as storage period advanced.

Table 11. Effect of salicylic acid and chitosan on titratable acidity % in juice fruit under cold storage and shelf life (2024 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	0.71	0.397	0.483	0.530	0.71	0.497	0.500	0.569
Salicylic acid at 1.0%	0.71	0.473	0.513	0.550	0.71	0.567	0.560	0.579
Chitosan acid at 1.0%	0.71	0.507	0.467	0.576	0.71	0.597	0.460	0.622
Chitosan acid at 2.0%	0.71	0.407	0.483	0.533	0.71	0.693	0.483	0.628
Control (Tap water)	0.71	0.447	0.483	0.546	0.71	0.580	0.520	0.603
Mean	0.71	0.446	0.485	—	0.71	0.586	0.504	—
LSD at 5%	Treatments (T)=0.062 Storage (S)=0.039 TxS=0.087				Treatments (T)=0.075 Storage (S)=0.047 TxS=0.106			

Table 12. Effect of salicylic acid and chitosan on titratable acidity % in juice fruit under cold storage and shelf life (2025 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	0.65	0.517	0.443	0.536	0.65	0.493	0.447	0.533
Salicylic acid at 1.0%	0.65	0.567	0.500	0.572	0.65	0.510	0.457	0.535
Chitosan acid at 1.0%	0.65	0.507	0.397	0.518	0.65	0.483	0.320	0.484
Chitosan acid at 2.0%	0.65	0.493	0.427	0.523	0.65	0.423	0.383	0.485
Control(Tap water)	0.65	0.507	0.427	0.528	0.65	0.493	0.337	0.493
Mean	0.65	0.5182	0.4388	—	0.65	0.4804	0.3888	—
LSD at 5%	Treatments (T)=0.029 Storage (S)=0.018 TxS=0.041				Treatments (T)=0.036 Storage (S)=0.022 TxS=0.051			

In both seasons, the titratable acidity of the fruits decreased over time, which is typical for many fruits as they ripen and undergo metabolic changes. The fruits treated with 1.0% Salicylic acid in both season exhibited the highest TA values during storage (0.513-0.500) after 30days of cold storage and (0.560-0.457) 3 days during shelf life, suggesting that this treatment helped preserve the acidic content of the fruits. Moreover, no significant differences were detected between the applied treatments and the control, either during cold storage or throughout the storage period in both seasons.

Titratable acidity is a key indicator of the fruit's maturity and flavor profile. The preservation of TA can be linked to the ability of the treatments to slow down the metabolic processes, including the breakdown of acids. Salicylic acid likely works by forming a semi-permeable coating that slows down respiration and moisture loss, which in turn reduces the rate at which acids are degraded.

Similar findings were observed in previous studies where chitosan coatings effectively delayed the reduction of acidity in fruits during storage (Hajiesmaeili and Danaee, 2024; Korićanac *et al.* 2024). These results are in line with the known preservative effects of chitosan, which has been demonstrated to maintain the sensory and nutritional properties of fruits during cold storage and shelf life.

7- SSC/ acid ratio in fruit:

Tables 13,14 illustrate the effects of different treatments with salicylic acid and chitosan on the SSC/acid ratio in fruits during cold storage and shelf life at room temperature for the 2024 and 2025 seasons. The SSC/acid ratio showed a gradual increase from harvest up to 30 days under cold storage or after 3 days at room temperature. This increase can be mainly attributed to the rise in soluble solids content accompanied by a decline in total titratable acidity of the fruit juice as storage progressed. The data also, showed that dipping "Solar Eclipse" plum fruits in 1.0% Salicylic acid gave a higher significant SSC/acid ratio in fruit juice than dipping fruits in control (29.51-31.76) after 30 days in cold storage and (31.95 - 41.82) after 3 days at room temperature during the tow respectively seasons.

The observed improvements in the SSC/acid ratio can be attributed to the distinct roles of salicylic acid and chitosan. Salicylic acid delays fruit senescence and enhances metabolic activity, enabling continued sugar accumulation and acid breakdown. Chitosan acts as a semi-permeable barrier, reducing water loss and preserving physiological functions within the fruit, which helps maintain a favorable sugar-to-acid balance. The gradual decline in the ratio in some treatments with prolonged storage reflects the cumulative effects of storage conditions on fruit quality.

These findings align with previous studies that highlighted the role of salicylic acid in improving fruit quality during storage by mitigating oxidative stress and regulating metabolic processes. Similarly, the results support the evidence of chitosan as a bio-coating agent that protects fruits from deterioration while enhancing sugar retention. These outcomes represent a crucial step toward optimizing storage techniques to maintain post-harvest quality and reduce agricultural losses (El-Kady *et al.* 2014).

Table 13. Effect of salicylic acid and chitosan on SSC/acid ratio in fruits under cold storage and shelf life (2024 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	21.81	42.97	28.77	31.18	21.81	32.87	29.06	28.02
Salicylic acid at 1.0%	21.81	30.75	29.51	27.02	21.81	27.97	31.95	25.64
Chitosan acid at 1.0%	21.81	27.27	28.82	26.30	21.81	26.03	27.16	26.59
Chitosan acid at 2.0%	21.81	38.94	28.88	29.87	21.81	25.16	31.05	26.00
Control(Tap water)	21.81	31.90	26.72	26.81	21.81	24.60	27.65	24.68
Mean	21.81	34.37	28.54	—	21.81	27.32	29.37	—

LSD at 5%	Treatments (T)=3.875 Storage (S)=2.450 TxS=5.480	Treatments (T)=4.458 Storage (S)=2.82 TxS=6.305

Table 14. Effect of salicylic acid and chitosan on SSC/acid ratio in fruits under cold storage and shelf life (2025 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	21.6	27.19	30.42	26.40	21.6	27.96	29.59	26.38
Salicylic acid at 1.0%	21.6	25.13	31.76	24.83	21.6	27.06	41.82	26.16
Chitosan acid at 1.0%	21.6	27.49	30.30	26.46	21.6	26.67	39.65	29.97
Chitosan acid at 2.0%	21.6	29.39	31.73	27.40	21.6	33.32	35.11	30.01
Control (Tap water)	21.6	28.12	27.21	26.97	21.6	28.07	29.02	29.56
Mean	21.6	27.46	30.28	—	21.6	28.61	35.03	—
LSD at 5%	Treatments (T)= 1.896 Storage (S)= 1.199 TxS=2.682				Treatments (T)=2.085 Storage (S)= 1.691 TxS=3.782			

8. Total anthocyanin content (mg/100 g FW)

Tables 15,16 presents the effect of salicylic acid and chitosan treatments at various rates on total anthocyanin content (mg/100 g FW) in fruits during cold storage and 3 days in shelf life at room temperature for the 2024 and 2025 seasons.

Table 15. Effect of salicylic acid and chitosan on fruit anthocyanin (mg/100 g FW) under cold storage and shelf life (2024 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at 0.5%	0.636	0.779	0.788	0.734	0.636	0.775	0.880	0.763
Salicylic acid at 1.0%	0.636	0.768	0.785	0.727	0.636	0.772	0.878	0.762
Chitosan acid at 1.0%	0.636	0.804	0.815	0.751	0.636	0.797	0.896	0.774
Chitosan acid at 2.0%	0.636	0.787	0.800	0.741	0.636	0.789	0.890	0.773
Control (Tap water)	0.636	0.755	0.777	0.725	0.636	0.754	0.858	0.749
Mean	0.636	0.778	0.793	—	0.636	0.777	0.880	—
LSD at 5%	Treatments (T)=0.0479 Storage (S)=0.0303 TxS=0.0677				Treatments (T)=0.0123 Storage (S)=0.0078 TxS=0.0175			

Table 16. Effect of salicylic acid and chitosan on fruit anthocyanin (mg/100 g FW) under cold storage and shelf life (2025 season)

Treatments	Days at cold storage				After 3 days of shelf life			
	0	15	30	Mean	0	15	30	Mean
Salicylic acid at rate of 0.5%	0.630	0.649	0.651	0.643	0.630	0.731	0.793	0.718
Salicylic acid at rate of 1.0%	0.630	0.650	0.660	0.647	0.630	0.726	0.772	0.709
Chitosan acid at rate of 1.0%	0.630	0.650	0.663	0.647	0.630	0.751	0.801	0.727
Chitosan acid at rate of 2.0%	0.630	0.636	0.650	0.635	0.630	0.709	0.759	0.698
Control (Tap water)	0.630	0.640	0.640	0.645	0.630	0.705	0.757	0.698
Mean	0.63	0.645	0.656	—	0.63	0.724	0.776	—
LSD at 5%	Treatments (T)=0.003 Storage (S)=0.002 TxS=0.004				Treatments (T)=0.003 Storage (S)=0.002 TxS=0.004			

The results indicate that both salicylic acid and chitosan treatments maintain the anthocyanin content compared to the control across all storage durations. In particular, chitosan treatments, especially at 1.0% consistently resulted in higher anthocyanin levels during both cold storage and shelf life in the 2024 season. The 2025 season data showed similar trends, with chitosan at 1.0% producing notable increases in anthocyanin content during shelf life. The control treatment exhibited the lowest anthocyanin levels, particularly during extended storage periods.

Peel color changed during storage conditions but chitosan coating delayed these colorimetric changes, probably due to a delay in the rate of ripening leading to the inhibition of anthocyanin synthesis, as reported in other studies (Modesti *et al*., 2019)

The observed enhancement of anthocyanin content with salicylic acid and chitosan can be attributed to their roles in delaying senescence and reducing oxidative stress. Salicylic acid likely stimulated the biosynthesis of anthocyanin by enhancing phenylpropanoid pathway activity, which is closely associated with anthocyanin production. Chitosan, on the other hand, likely acted as a biostimulant and protective coating, reducing degradation of anthocyanin during storage. The consistent drop in anthocyanin levels after prolonged storage for the control group highlights the impact of oxidative and enzymatic degradation under untreated conditions. The obtained results are in harmony with those of El-Kady *et al.* (2014); Kumar *et al.* (2017); Bal, (2013).

CONCLUSION

This study demonstrated that postharvest treatments with salicylic acid and chitosan improved the storage ability and overall quality of “Solar Eclipse” plum fruits. While 1.0% salicylic acid was significantly more effective, both treatments contributed to delaying deterioration, maintaining firmness, and preserving sensory attributes during storage. Although salicylic acid and chitosan may be showed the most promising effect in extending shelf life and reducing postharvest losses; however, further investigations are necessary to support and expand these observations.

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دراسات تأثير حامض الساليسيليك والشيتوزان على القدرة التخزينية لثمار البرقوق "سولار إكليبس"

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الملخص

تهدف هذه الدراسة إلى تقييم تأثير معاملات ما بعد الحصاد باستخدام حامض الساليسيليك والشيتوزان بتركيزات مختلفة على جودة ثمار البرقوق صنف "سولار إكليبس" أثناء التخزين. أُجريت التجربة على مدار موسمين (2024-2025) علي ثماراشجار منزرعه في تربة رملية بنظام الري بالتنقيط، وشملت خمس معاملات: حمض الساليسيليك (٠,٥٪ و١,٠٪)، الشيتوزان (١,٠٪ و٢,٠٪)، والكنترول (ماء الصنبور). تم تخزين الثمارفي درجة حرارة ٤ ± ١°C و رطوبة نسبية تتراوح بين ٩٠–٩٥٪، وتم تقييمها بعد ١٥ و٣٠ يومًا من التخزين البارد، بالإضافة إلى التقييم بعد فتره تخزين لمدة ٣ أيام في درجة حرارة الغرفة لتقييم التغيرات في الخصائص الفيزيائية والكيميائية تحت الظروف المحيطة. أظهرت النتائج أن جميع المعاملات أثرت بشكل معنوي على الفقد فى الوزن، والحفاظ على الصلابة، ومحتوى المواد الصلبة الذائبة، ومحتوى الأنثوسيانين. كما قللت جميع المعاملات من الفقد في وزن الثمار مقارنة بالكنترول. حيث بلغت نسبة الفاقد فى وزن ثمار الكنترول (٦,٥٠٪ و٥,٢١٪) بعد ٣٠ يومًا من التخزين البارد. ومع ذلك، أدى نقع ثمار برقوق "سولار إكليبس" في حمض الساليسيليك بتركيز ١٪ إلى خفض كبير في فقدان وزن الثمار، حيث تراوحت النسبة بين (٤,٩١٪ و٤,٧٧٪) بعد ٣٠ يومًا من التخزين البارد خلال الموسمين. كما أن نقع الثمار في الشيتوزان بتركيز ١٪ أو ٢٪ أظهر قيمة أقل من الثمار غير المعاملة. وقد أثر الشيتوزان والساليسيليك بشكل إيجابي على معظم صفات الجودة للثمار.